MODULE 00104 v6.0

Introduction to Power Tools

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MODULE 00104

Introduction to Power Tools

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Objectives

Successful completion of this module prepares you to do the following:

1. Identify and explain how to use various types of power drills and impact wrenches.
   a. Summarize basic power tool safety guidelines.
   b. Identify common power drills and bits and explain how to use them.
   c. Describe the difference between hammer drills and impact drivers.
   d. Identify pneumatic drills and impact wrenches and explain how to use them.
2. Identify and explain how to use various types of power saws.
   a. Explain how to use a circular saw and identify different types of blades.
   b. Differentiate between jigsaws and reciprocating saws and explain how to use them.
   c. Explain how to use a portable band saw.
   d. Describe the difference between miter saws and cutoff saws.
   e. Explain how to use table saws and describe the types of jobs for which they are best suited.
3. Describe the types of jobs best suited to grinders and oscillating multi-tools.
   a. Explain how to use various types of grinders.
   b. Identify grinder accessories and the jobs for which they are used.
   c. List the type of jobs that can be performed using an oscillating multi-tool.
4. Identify and explain how to use miscellaneous power tools.
   a. Discuss the hazards of using power nailers.
   b. Describe jobs that can be performed with hydraulic jacks.

Performance Task

Under supervision, you should be able to do the following:

1. Safely and properly demonstrate the use of the following tools:
   - Electric drill (corded and cordless)
   - Hammer drill
   - Impact driver
   - Circular saw
   - Jigsaw
   - Reciprocating saw
   - Portable band saw
   - Miter or cutoff saw
   - Table saw

- Portable or bench grinder
- Oscillating multi-tool
- Power nailer

Overview

Power tools play an important role in the construction industry. Thousands of construction workers across the world use power tools every day to make holes; cut different types of materials, smooth rough surfaces, and shape a variety of products. Regardless of their specialization, all construction workers eventually use power tools on their job. This module provides an overview of the common types of power tools and how they function. It also describes the proper techniques required to ensure their safe and efficient operation.

Industry Recognized Credentials

If you are training through an NCCER-accredited sponsor, you may be eligible for credentials from NCCER's Registry. The ID number for this module is 00104. Note that this module may have been used in other NCCER curricula and may apply to other level completions. Contact NCCER's Registry at 888.622.3720 or go to **www.nccer.org** for more information.

1.0.0 Power Drills/Drivers

Performance Task

1. Safely and properly demonstrate the use of the following tools:
   - Electric drills/drivers (corded and cordless)
   - Hammer drill
   - Impact driver

Objective

Identify and explain how to use various types of power drills and impact wrenches.

a. Summarize basic power tool safety guidelines.
b. Identify common power drills and bits and explain how to use them.
c. Describe the difference between hammer drills and impact drivers.
d. Identify pneumatic drills and impact wrenches and explain how to use them.

Alternating current (AC): The common power supplied to most all wired devices, where the current reverses its direction many times per second. AC power is the type of power generated and distributed throughout settled areas.

Direct current (DC): An electric power supply where the current flows in one direction only. DC power is supplied by batteries and by transformer-rectifiers that change AC power to DC.

This module introduces four categories of power tools:

- *Electric tools (corded and cordless)* — These tools are powered by either of two types of electricity: **alternating current (AC)** or **direct current (DC)**. Tools powered by AC, plug into a wall receptacle using an integrated power cord. DC-powered tools, known as cordless tools, operate on rechargeable batteries and make up the vast majority of power tools used on today's construction sites.
- *Pneumatic tools* — These tools are powered by air. Electric or gasoline-powered compressors produce the air pressure. Air hammers and pneumatic nailers are examples of pneumatic tools.
- *Specialty tools* — These tools include powder-actuated fastening tools that use gun powder to drive pins and studs into concrete and steel. Power-actuated tools require special training and certification to use.
- *Hydraulic tools* — These tools are powered by fluid pressure. Hand pumps or electric pumps are used to produce the fluid pressure. Pipe benders, jackhammers, and wrenches are examples of hydraulic tools.

Before reviewing specific types of tools from each of these categories, it is important to address general safety guidelines that apply to all power tools, regardless of category.

1.1.0 Basic Power Tool Safety Guidelines

Always remember, if not used properly, power tools have the potential to be dangerous. Safety guidelines are covered for each power tool in this module, but general safety issues—safety in the work area, safety equipment, and working with electricity—are covered in the NCCER Module 00101, *Basic Safety (Construction Site Safety Orientation)*. This information is vital for working with power tools.

WARNING!

Remember that appropriate personal protective equipment (PPE) must be worn when operating any power tool or when near someone else who is operating a power tool.

Basic safety guidelines that must be followed when working with all power tools include the following:

- Always read and follow guidelines provided in the power tool's *Operating Instructions* before attempting to use it.
- Never operate power tools without proper instruction and supervision.
- Confirm you have the right power tool for the job.
- Make sure the tool has been disconnected from its source of energy when not in use and before performing maintenance or replacing parts, such as bits, blades, or discs.
- Regularly inspect power tools, including power cords and hoses, for damage. Report any damaged tools to your supervisor.
- Proper PPE, including safety glasses, are required, regardless of what power tool is in use. Some tools require the use of a face shield in addition to safety glasses. Safety shoes should also be worn, and tight-fitting gloves are required for most power tools. Loose gloves can be a safety hazard of their own.
- Keep other craftworkers who are not directly involved with the work at a safe distance.
- Do not wear loose-fitting clothing that could be caught in the mechanism of your power tool.
- Never use electric power tools in wet conditions unless they are approved for this type of application. In all cases, when a power tool has a three-pronged plug, make certain it is plugged into a grounded receptacle. Additionally, before plugging into a receptacle, confirm the power switch on the tool is set to the Off position.
- If a power tool is equipped with a **trigger lock**, do not use the lock. A trigger lock is a small lever, switch, or part that can be used to activate a locking catch or spring to hold a power tool trigger in the operating mode even when the trigger is released. Locking any power tool in the On position can be very dangerous.

Trigger lock: A small lever, switch, or part that can be used to activate a locking catch or spring to hold a power tool trigger in the operating mode without finger pressure.

WARNING!

The use of trigger locks may be prohibited by an employer or job site. If a power tool is equipped with a trigger lock, DO NOT activate it.

- Never carry an electric or pneumatic tool by its cord or hose.
- Do not allow yourself to be distracted while using a power tool. If you are distracted or interrupted while operating the tool, turn it off.

1.2.0 Types of Power Drills/Drivers

Various types of power drills, also known as *drivers*, are used in the construction industry. A power drill is most commonly used to make holes by spinning drill bits into wood, metal, plastic, or other materials. With different attachments and accessories, the power drill can be also used as a sander, polisher, screwdriver, grinder, or **countersink**.

Countersink: A bit or drill used to set the head of a screw at or below the surface of the material.

The most common types of power drivers include the following:

- Electric (corded) drills
- Electric cordless drills
- Electromagnetic (mag drill press) drills
- Hammer drills and impact drivers
- Pneumatic drills and wrenches
- Electric screwdrivers

1.2.1 Power Drills and Bits

Most power drills have several common features. For example, most have a pistol grip with a trigger switch for controlling power (*Figure 1*).

The farther back the trigger of a variable-speed drill is pulled, the faster the drill spins. Drills also have reversing switches that enable the drill to spin backwards in order to back the drill bit out if it gets stuck in the material while drilling. Power drills use replaceable bits for different drilling tasks (*Figure 2*). On variable-speed power drills, a screwdriver bit can be used in place of a drill

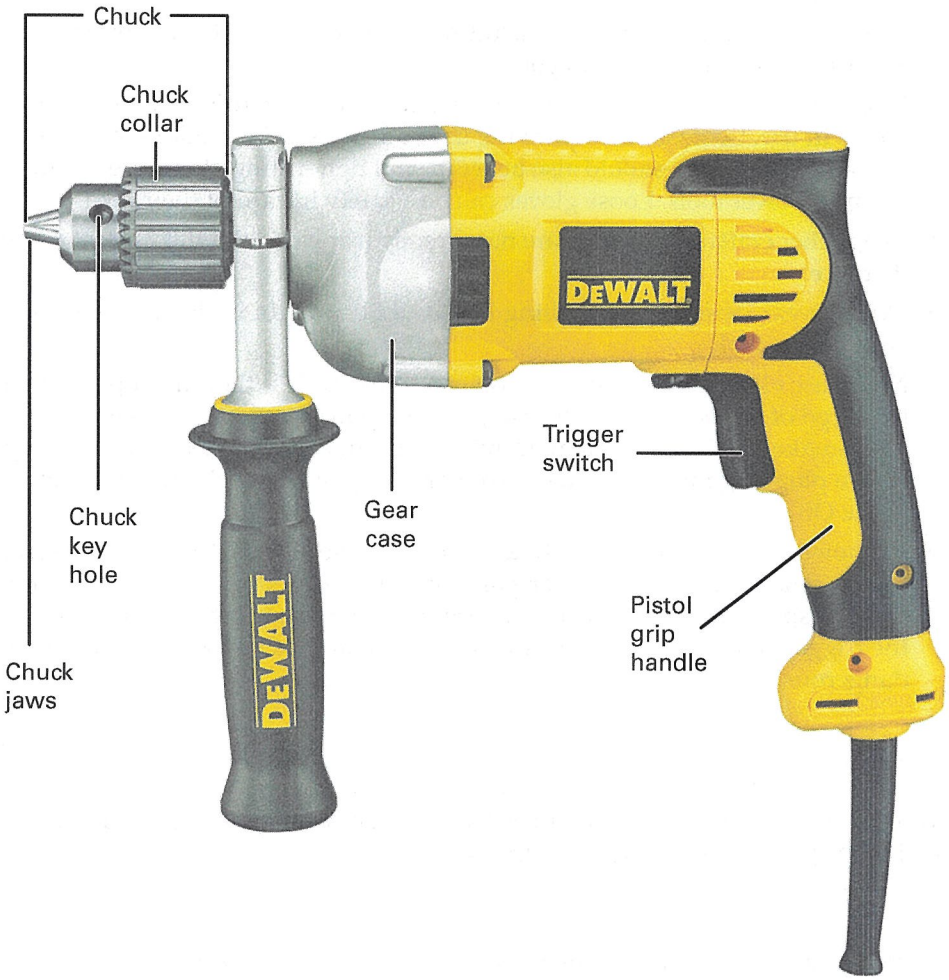


Figure 1 Parts of power drill.
Source: Image property of Stanley Black & Decker. Used with permission

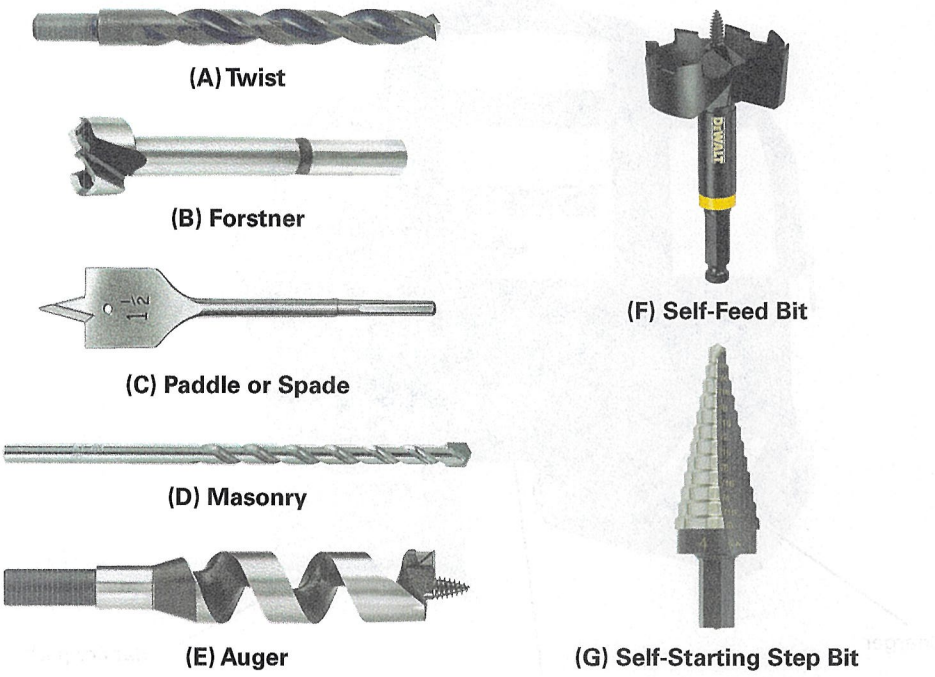


Figure 2 Drill bits.
Source: Image property of Stanley Black & Decker. Used with permission (2A, 2D–2G); Courtesy of Milwaukee Electric Tool Corporation (2B–2C)

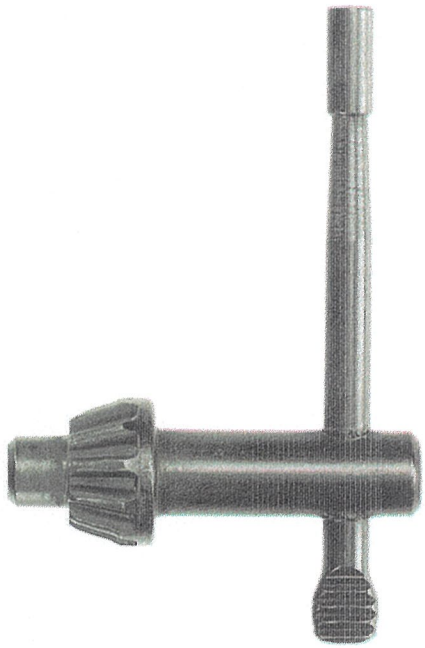


Figure 3 Chuck key.
Source: Image property of Stanley Black & Decker. Used with permission

bit so that the drill can be used as a screwdriver. Only use screwdriver bits designed for use in a power drill.

Twist drill bits are used to drill wood and plastics at high speeds or to drill metal at a lower speed. A **Forstner bit** is used on wood and is particularly good for boring a flat-bottom hole. A paddle bit or spade bit is also used in wood. The bit size is measured by the paddle's diameter, which generally ranges from ½ to 1½ inches (≈13 to 38 mm). A **masonry bit**, which has a carbide tip, is used in concrete, stone, slate, and ceramic material. The **auger bit**, which is designed to turn at low speeds, is used for drilling wood and other soft materials, but not for drilling metal. A **self-feed bit** uses a lead screw that pulls the larger, rear portion of the bit into the wood, making it simple to drill larger holes. The **step drill bit** is perfect for drilling holes in metal up to ¼ inch thick. As the name implies, this bit includes different 'steps' that allow the user to cut a hole to a desired diameter.

Forstner bit: A bit designed for use in wood or similar soft material. The design allows it to drill a flat-bottom blind hole in material.

Masonry bit: A drill bit with a carbide tip designed to penetrate materials such as stone, brick, or concrete.

Auger bit: A drill bit with a spiral cutting edge for boring holes in wood and other materials.

Self-feed bit: A drill bit that uses a lead screw to pull the larger rear portion of the bit into the wood, making it simple to drill larger holes.

Step drill bit: A drill bit that includes steps which enable the user to cut holes in metal to a desired diameter.

Drill bit sizes can vary a great deal. For most applications, bits are available in both fractional-inch sizes and metric sizes. For twist drill bits, common fractional-inch sizes range from 1/64-inch to 1 inch. Common metric sizes for twist drill bits range from 0.5 mm to 25.0 mm. It is important to note that fractional-inch bits and metric bits are not directly interchangeable. In other words, no fractional-inch bit has a corresponding metric bit, and vice versa. However, twist drill bits are also available in sets of numbered and lettered bits. Numbered sets range from #80 up to #1, which is the largest of the set. The next bit size larger is the A bit, with the Z bit being the largest of the lettered set. These sets correspond to decimal fraction and metric sizes. For example, a #8 drill bit is sized at 0.199 inches and 5.055 mm. Number and letter drills are used or specified when the precise size of the hole is important.

Bits are held in a drill by the drill **chuck**. Keyed chucks are opened and closed using a **chuck key** (*Figure 3*). Chuck keys are typically interchangeable in design, but there are several different sizes. Keyless chucks are typically found on cordless drills. Remember that the size of the chuck limits the size of the bit or tool a drill can accommodate.

Chuck: A clamping device that holds an attachment; for example, the chuck of the drill holds the drill bit.

Chuck key: A small, T-shaped steel piece used to open and close the chuck on power drills. Cordless drills typically do not have a chuck key.

1.2.2 Cordless Tools and Batteries

The vast majority of tools on today's construction sites are cordless. Cordless tools offer two important benefits: safety and mobility. They are safer, and more mobile,

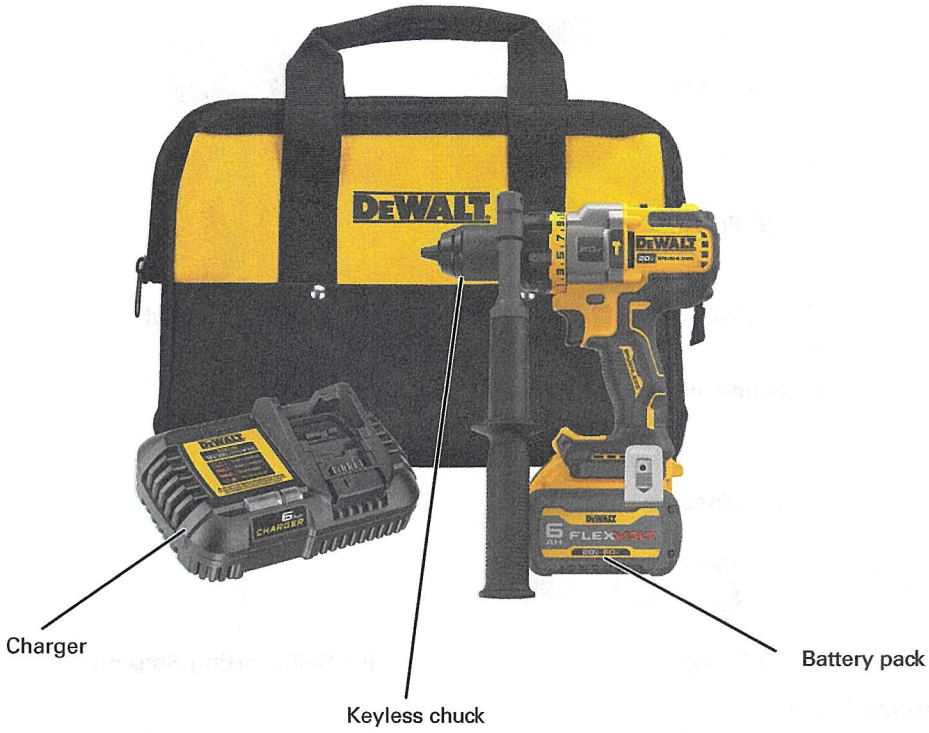


Figure 4 Cordless drill.
Source: Image property of Stanley Black & Decker. Used with permission

because they lack cumbersome power cords that can cause people to stumble and fall, and they are handy for working in areas where a power source is unavailable.

Cordless drills (see *Figure 4*) use a battery pack to power the motor. There are three battery pack types commonly used with today's cordless tools: Nickel-Cadmium (NiCd), Nickel-Metal Hydride (NiMH), and Lithium-ion (Li-ion).

The battery pack can be detached and plugged into a battery charger any time the tool is not in use. Some chargers can recharge the battery pack quickly, while others require extended periods of charging time. The quality of charge and the lifecycle of the battery must be considered when determining how to best charge the battery. Li-ion batteries have several advantages over the other NiCd and NiMH batteries, including offering the highest number of **charge cycles** as well as the ability to run the longest on a full charge. The charge cycle describes one complete charge and discharge cycle of the tool's rechargeable battery.

Charge cycles: Describe one complete charge and discharge cycle for a rechargeable battery.

Amp hour (Ah): A rating that describes the maximum amps a battery can provide continuously for up to 60 minutes. Drawing more amps than the battery's rating is possible, but it reduces the amount of time before the battery is drained.

Voltage rating: A measurement of the power the tool can deliver.

The term **Amp hour (Ah)** describes the maximum amps a battery can provide continuously for up to 60 minutes. Drawing more amps reduces the time before the battery is drained and needs to be recharged. For example, under ideal conditions, a 4Ah battery is capable of providing up to 4 amps continuously for one hour before the battery is drained. Drawing 8 amps from the same battery reduces the same tool's runtime to 30 minutes.

One other critical factor to consider when using cordless tools is the battery's **voltage rating**. A cordless tool's voltage rating is actually a measurement of its power. The higher the voltage, the more power the tool can deliver for the job.

Regardless of the battery type, every manufacturer provides information related to the strength and life of the battery in their product literature. Craftworkers who use cordless tools often carry extra battery packs with them.

Some cordless drills have adjustable clutches so that the drill motor can serve as a power screwdriver without applying too much power to the screw. Note that only heavy-duty cordless drills use keyed chucks, while the vast majority are keyless.

1.2.3 Power Drill Safety and Maintenance Guidelines

In addition to following basic power tool safety guidelines, familiarize yourself with these power drill safety rules before operating a power drill:

- Always wear the appropriate PPE when working with drills, especially safety glasses.
- Disconnect the power source (power cord or battery) before performing maintenance or changing drill bits.
- Keep your hands away from the drill bit and chuck.

WARNING!

Keep your hands away from a spinning drill bit. The spinning bit will cut your hands. Keep an even pressure on the drill to keep the drill from twisting or binding.

- When using a corded drill, operate only tools that are double-insulated electric power tools with proper **ground fault protection**. Using a **ground fault circuit interrupter (GFCI)** device protects equipment from continued electrical current in case of a circuit fault. The GFCI monitors the current flow and opens the circuit (which stops the flow of electricity) if it detects a difference between positive and negative flow.
- When using power drills with two-prong plugs, confirm that they are double-insulated. Tools that are not double insulated must have a third prong to provide a ground circuit. Do not use a power drill if the ground prong on the plug is broken off.
- Before connecting a drill to its power source, confirm the trigger is NOT turned on.
- To avoid hitting water lines or electrical wiring when drilling through a wall or partition, verify what is inside the wall or on the other side of the work surface beforehand.

Ground fault protection: Protection against short circuits; a safety device cuts power off as soon as it senses any imbalance between incoming and outgoing current.

Ground fault circuit interrupter (GFCI): A circuit breaker designed to protect people from electric shock and to protect equipment from damage by interrupting the flow of electricity if a circuit fault occurs.

WARNING!

Do not drill into or through a wall before confirming what is on the other side. Take steps to avoid hitting anything that would present a safety hazard or cause damage. Spaces between studs (upright pieces in the walls of a building) often contain electrical wiring, plumbing, or insulation. Care must be taken to avoid drilling directly into the wiring, pipes, or insulation.

- Prior to drilling, select the proper bit for the job and make sure it is sharp. Make sure the drill bit is tightened securely in the chuck before using it.
- When using drills with keyed chucks, attach the key to the power cord to ensure the key is available when tightening or loosening a bit.
- Hold the drill with both hands and apply steady pressure.
- Never ram the drill while drilling because the force can chip the cutting edge and damage the bearings.
- As noted earlier, never use a drill's trigger lock to hold the trigger in the operating mode.
- Do not overreach when using a power drill; maintain a stable and balanced stance.
- Keep your power drill clean at all times.

Figure 5 Right-angle drills.
Source: Courtesy of Milwaukee Electric Tool Corporation

WARNING!

If power tools are shared between workers, it is important NOT to grab the tool by the bit or any other moving part. Power tools should be disconnected from their source of power whenever they are passed between workers to avoid accidental startups. Hand off tools by their handles and/or bodies only.

1.2.4 Preparing to Use a Power Drill

CAUTION

Power drills can be dangerous if you do not use them properly. Always wear the proper PPE, including appropriate eye, head, and hand protection.

Prior to using a drill, make sure the one you plan to use is designed to perform the task at hand. Some electric power drills are made to be used in tight spaces, such as between studs and joists. Drills like those shown in *Figure 5* are referred to as right-angle drills. The drill on the right is larger and develops more power for larger holes.

Preparing Drills with Keyed Chucks

Once the proper drill has been selected, it is time to prepare it for use. Follow the steps below to prepare the power drill:

Step 1 Disconnect the drill from its power source.

Step 2 Turn the chuck counterclockwise (to the left) until the chuck opening is large enough to insert the bit **shank**. The shank is the smooth part of the bit.

Step 3 Insert the bit shank into the chuck opening (*Figure 6A*). Keeping the bit centered in the opening, turn the chuck by hand until the jaws grip the bit shank.

Step 4 Insert the chuck key (*Figure 6B*) into one of the holes on the side of the chuck and turn the key clockwise (to the right) to tighten it. With larger chucks, you can tighten the individual jaws of the chuck uniformly by inserting and tightening the key in each of the holes on the chuck. Remove the key from the chuck once it is tightened. You are now ready to use the electric drill.

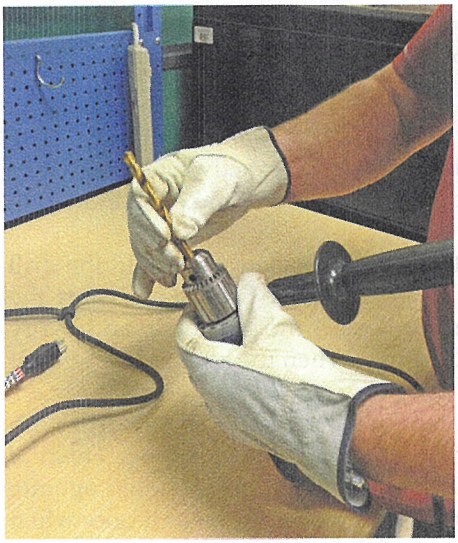
Shank: The smooth part of a drill bit that fits into the chuck.

NOTE

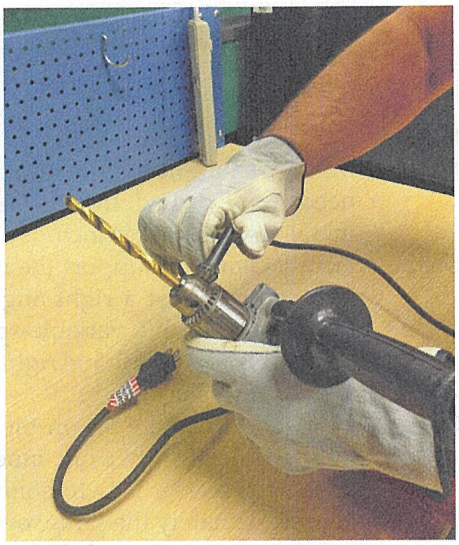
The chuck key has a grooved ring called a gear. Make sure that the proper size chuck key is used so that the key's gear meshes with the matching gears on the end of the chuck.

WARNING!

Do not forget to remove the key from the chuck after it has been tightened. Otherwise, when you start the drill, the key could fly out and injure you or a co-worker.



(A) Insert the Bit Shank into the Chuck Opening.



(B) Tighten with the Chuck Key.

Figure 6 Loading the bit on a keyed chuck.
Source: Cianbro Corporation

Preparing Drills with Keyless Chucks

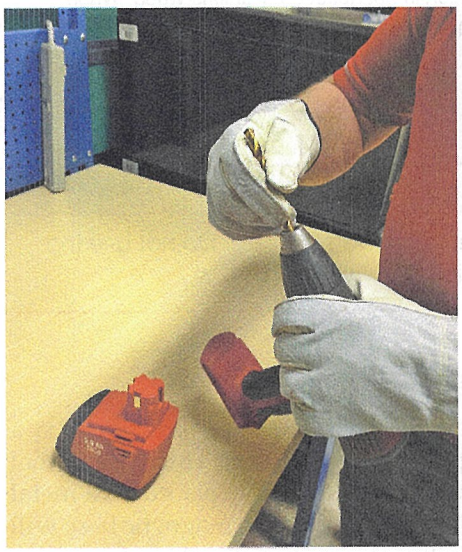
Most cordless drills use a keyless chuck. While the steps for preparing a cordless drill are similar, there are some small differences. Follow the steps below when preparing to use drills with keyless chucks:

Step 1 Disconnect the drill from its power source by removing the battery pack before loading a bit.

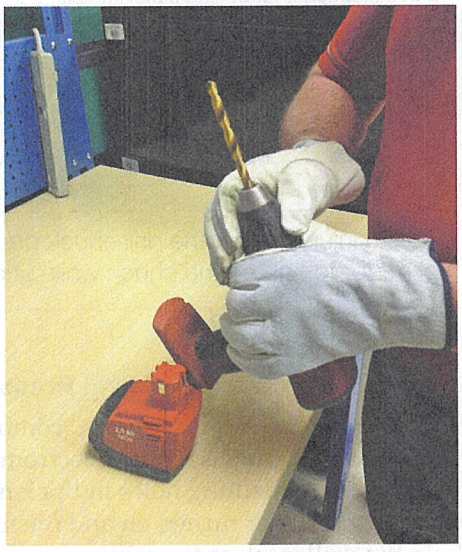
Step 2 As shown in (*Figure 7A*), open the chuck by turning it counterclockwise until the jaws are wide enough to insert the bit shank.

Step 3 Insert the bit shank into the chuck opening (*Figure 7B*). Keeping the bit centered in the opening, turn the chuck by hand until the jaws grip the bit shank.

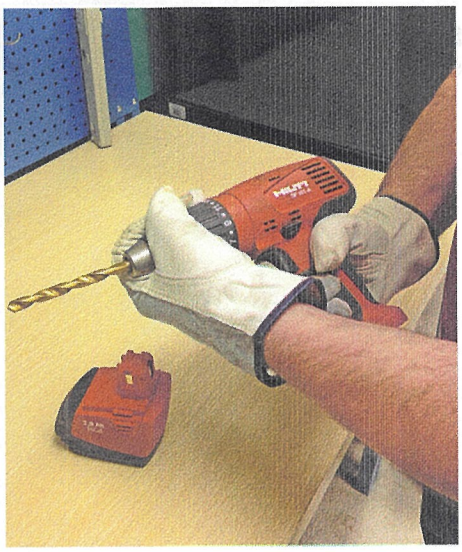
Step 4 Tighten the chuck securely with your hand so that the bit does not move (*Figure 7C*). You are now ready to use the cordless drill.



(A) Insert the Bit Shank.



(B) Keep Bit Straight and Partially Tighten the Chuck.



(C) Tighten the Chuck Securely.

Figure 7 Loading the bit on a keyless chuck.
Source: Cianbro Corporation

1.2.5 Operating Power Drills

After securing the bit, connect the drill to its power source. Use the following steps to operate the power drill:

Step 1 Put on the appropriate PPE.

Step 2 Make a small indent or mark on the material exactly where the hole needs to be drilled. In wood, use a small punch to make the indent; in metal, use a center punch.

Step 3 Firmly clamp or support the material being drilled, then hold the drill perpendicular (at a right angle) to the material surface and start the drill motor. With a variable-speed drill, start the bit slowly and verify the drill is rotating in the right direction. (When the bit is faced away, it should turn clockwise.)

Step 4 Place the tip of the bit on the indent or mark and hold the drill with both hands. Apply only moderate pressure when drilling. *Figure 8* shows the proper way to hold the drill. The drill motor should operate at approximately the same **revolutions per minute (rpm)** as it does when pressure is not exerted. If the sound of the drill indicates it is slowing considerably, apply less pressure.

Step 5 Reduce the pressure when the bit is about to emerge from the other side of the work, especially when drilling metal. If the drill bit gets stuck in the material during drilling, release the trigger, use the reversing switch to change the direction of the drill, and gently back it out of the material.

Revolutions per minute (rpm): The rotational speed of a motor or shaft, based on the number of times it rotates each minute.

Figure 8 Properly holding a drill.
Source: Cianbro Corporation

WARNING!

As the drill bit emerges through the opposite side of the material, be prepared for it to grab. With power still on, the tendency of the drill motor is to rotate the operator, and not the bit. Be sure to maintain firm control if this happens.

Drilling Metal

When drilling metal, it is best to lubricate the bit to help cool the cutting edges and produce a smoother finished hole. A small amount of non-combustible cutting oil or tapping fluid makes a good lubricant for drilling softer metals. Lubrication is *not* needed for drilling wood. When drilling deep holes, pull the drill bit partly out of the hole occasionally. Doing so clears the hole of shavings.

WARNING!

To avoid injury, adjust the drill chuck properly prior to each use. Do not use the tool motor to tighten the chuck while gripping it.

1.2.6 Electromagnetic Drill Presses

An electromagnetic drill press, commonly known as a *mag drill press,* is a portable drill mounted on an electromagnetic base (*Figure 9*). This type of tool is designed for drilling holes in thick metal. Once the drill is placed on a metal surface, the power turned on and the magnet energized, the magnetic base will hold the drill in place for drilling. Some drills can also be rotated in place while the base remains stationary.

Going Green

Recycling Rechargeable Batteries

Recycling rechargeable batteries once their power supply has become exhausted is no longer a luxury; it has become a matter of necessity. In fact, federal and state laws now regulate the disposal of some types of rechargeable batteries.

The US Environmental Protection Agency (EPA) estimates that more than 350 million rechargeable batteries are purchased annually in the United States. Likewise, hundreds of millions of rechargeable batteries and cellphones are retired each year. Rechargeable batteries are made using heavy metals and elements such as nickel, lithium, cadmium, mercury, and lead. All of these elements can be toxic to people and the environment if not disposed of properly. Most landfills are not designed to handle the toxic metals that will eventually leak out of the batteries.

Rechargeable batteries are commonly found in the following:

- Cordless power tools
- Cellular and cordless phones
- Two-way radios
- Laptop computers
- Digital cameras
- Camcorders

If a battery is rechargeable, then it is recyclable. Not only are rechargeable batteries better for the environment if they are discarded properly, but they are more cost effective. Using rechargeable batteries can help save money and protect the environment at the same time.

Recently, most cities have added hazardous waste collection centers that collect both rechargeable and regular batteries, along with paint, oil, refrigerant, and other hazardous wastes.

A switch on the junction box controls the electromagnetic base. When the switch is turned on, the magnet holds the drill in place on any surface with magnetic characteristics, such as carbon steel. The drill base must be clean and the surface must be flat. The switch on the top of the drill turns the drill motor on and off. A depth gauge can be used to set the depth of the hole being drilled. It operates like a drill press, with the operator turning a hand wheel to raise and lower the drill against the workpiece. Workers who use electromagnetic drills should be properly trained to safely operate the specific drill being used.

Figure 9 Electromagnetic drill press (mag drill press).
Source: Image property of Stanley Black & Decker. Used with permission (Photo)

Figure 10 Electromagnetic drill with safety chain.
Source: Cianbro Corporation

There are several safety rules specific to mag drill presses, including the following:

- Securely clamp the material being drilled by the press. Unsecured materials can become dangerous flying or spinning objects.
- Since mag drill presses are mounted onto an electromagnetic base, it is important to maintain electrical power to the drill's electromagnet. To prevent the electrical power supply from being interrupted, attach a *Do Not Unplug* tag (*Figure 9*) to the cord.

WARNING!

Removing power from an electromagnetic drill while it is in use can cause the drill to fall, potentially harming the operator.

- Use a safety chain to secure the electromagnetic drill in case power is lost or shut off (*Figure 10*).
- Before using a mag drill press on a construction site, confirm whether safety attachments must be used. Some sites require shields and/or safety lines to be attached before a mag drill press can be operated.

1.3.0 Hammer Drills and Impact Drivers

A hammer drill (*Figure 11*) has a light pounding action that enables it to drill into concrete, brick, or tile. The bit rotates and hammers at the same time, allowing faster drilling in these types of hard materials than would be possible with a regular drill. When the hammering action is disabled on these drills, they can also perform basic drilling tasks using other types of bits. The depth gauge on a hammer drill can be set to the depth of the hole to be drilled.

Special bits used with hammer drills are designed for pounding while they are turning. As a result, the bits used for drilling holes in masonry and rock have very hard tips, which are frequently made from **carbide**. Carbide-tipped bits are actually made by coating the tip of the drill bit with a mixture of tungsten carbide and cobalt baked at extremely high temperatures. The result is a tip that is much harder than those found on common bits.

Carbide: A very hard material made of tungsten carbide and heavy metals such as cobalt. Commonly baked on to the tips of masonry bits and to the edges of saw blades.

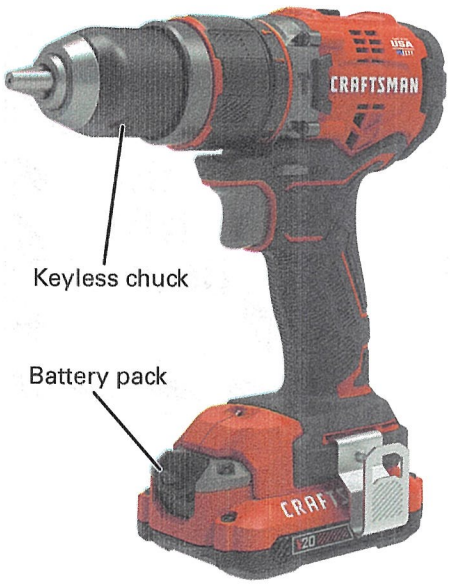


Figure 11 Hammer drill.
Source: Image property of Stanley Black & Decker. Used with permission

Did You Know

Almost as Hard as Diamonds

The hardness of a substance is often determined using the Rockwell hardness scale. To determine where a substance's hardness falls on the scale, a Rockwell hardness tester presses a pointed diamond into the substance being tested. The amount of force and depth of the indention determines the substance's hardness, which is shown as a number on the scale. Higher numbers indicate harder substances. By comparison, diamonds are one of the only substances harder than tungsten carbide. This is the reason carbide-tipped bits are harder and last much longer than regular drill bits.

The term *hammer drill* is often used to describe all tools that hammer and drill. However, rotary hammers (*Figure 12*) are designed for much heavier jobs than a typical hammer drill. They usually have slower rotational speeds than hammer drills, and strike harder and less often. Most rotary hammers require bits that fit into special chuck designs (*Figure 13*), so selected masonry bits must be compatible with the type of chuck on the tool. Chucks on rotary hammers are not keyed, but rely upon the design of the bit and chuck to hold it in place. Adapters are also available to use one bit shank design with another type of chuck when necessary.

Figure 12 Rotary hammer.
Source: Image property of Stanley Black & Decker. Used with permission

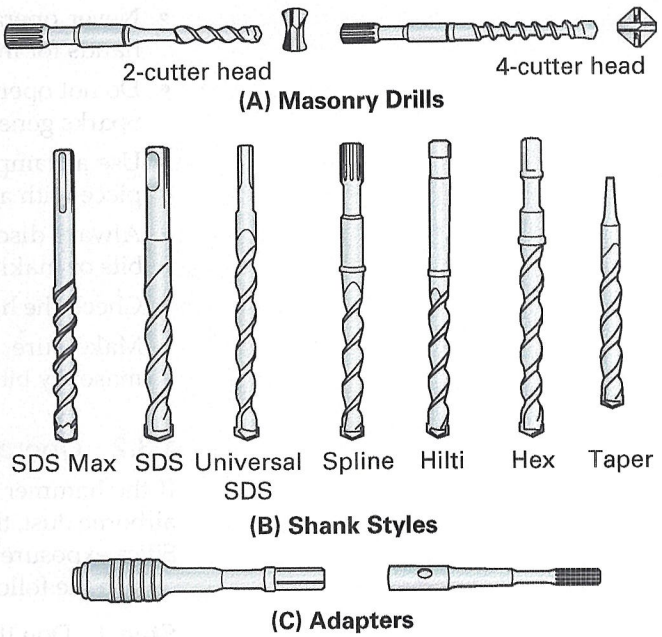


Figure 13 Rotary hammer bit designs.

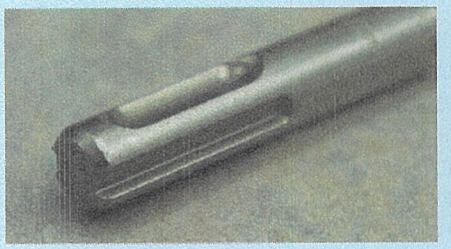
Did You Know

SDS Plus Vs SDS Max Drill Bits

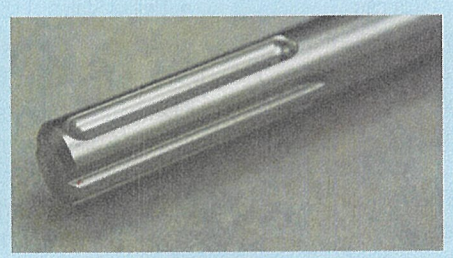
SDS technology originated in the mid-1970s when Hilti & Bosch introduced a new way of fastening bits to hammer and rotary drills. In the early days of the technology, many people insisted the letters SDS stood for the German words Stecken – Drehen – Sichern, which translates to Insert, Twist, and Secure. Today, SDS is known to refer to a Slotted Drive System.

When it was introduced, SDS allowed rotary hammers to lock a bit in place while still allowing the bit to move up and down. Because the chuck was spring loaded, SDS bits could be pushed into the chuck without having to tighten them. The next evolution of the system came with the introduction of SDS Plus, which offered an improved connector yet remained backward compatible with standard SDS bits. Finally, the SDS Max system was introduced to handle the heaviest masonry and steel drilling jobs.

SDS Plus bits range in sizes from 5/32" to 1¼", with thin wall carbide core bits up to 4" in length. SDS Max bits range from ½"–2", with thick wall carbide core bits up to 4" in length.



SDS Plus



SDS Max

Source: Belts And Boxes

1.3.1 Hammer Drill Safety and Maintenance

In addition to following basic power tool safety guidelines, before operating a hammer drill familiarize yourself with these safety rules:

- Always wear the appropriate PPE when working with hammer drills, especially safety glasses and hearing protection.

- Never operate hammer drills or rotary hammers with one hand. Use both hands for maximum control.
- Do not operate hammer drills or rotary hammers near flammable materials. Sparks generated by the bits may ignite them.
- Use a clamp to secure smaller or lighter work pieces and never hold a work piece with any part of your body.
- Always disconnect the hammer drill from its power source before changing bits or making any adjustments.
- Check the hammer drill and bit for damage prior to using it on a job.
- Make sure you are using the correct bit for the job. Using regular, non-masonry bits on concrete can damage or destroy the bit.

1.3.2 Operating Hammer Drills

If the hammer drill is being used on concrete or similar materials that produce airborne dust, there are important silica exposure standards that must be followed. Silica exposure standards are outlined in the NCCER Module 00101, *Basic Safety*.

Use the following steps to operate a hammer drill:

Step 1 Don the appropriate PPE.
Step 2 Ensure you have selected the appropriate drill bit for the job. If you need to replace the bit, disconnect the drill from its power source prior to doing so. Once the bit has been replaced, reconnect the drill to its power source.
Step 3 Make a small indent or mark on the material exactly where the hole needs to be drilled.
Step 4 Set the number of blows the bit will exert each minute.
Step 5 Set the drill to turn slowly.
Step 6 Place the tip of the bit on the indent or mark, then apply pressure on the drill against the surface.
Step 7 Drill a guide hole until it is approximately ¼" deep.
Step 8 Adjust the speed of the hammer drill to the desired speed and finish the job.
Step 9 Clean out the hole when finished.

Around the World

Power Sources

Each country provides power to its residents at a voltage and frequency that they believe best for the residents' needs. While the voltage often varies slightly from the target voltage, most power tools can accommodate these minor day-to-day differences. However, users must always ensure that the power supply for a given tool is appropriate. Although slight changes in voltage do not represent a problem, changes in power frequency and significant changes in the voltage will damage or destroy a power tool.

Here are the power characteristics for single-phase power from several different countries to show their differences. Note that the frequency, reported in hertz (Hz), refers to the cyclic nature of alternating current (AC) and how many cycles are completed per second:

- Portugal: 230 volts @ 50 Hz
- Hungary: 220 volts @ 50 Hz
- England: 240 volts @ 50 Hz
- Sweden: 230 or 400 volts @ 50 Hz
- United States: 115 or 230 volts, 60 Hz

The United States is one of very few countries that provide power at 60 Hz. Many devices can operate using power from almost all international power systems. These devices are often battery-charging devices that use a transformer to reduce the voltage and change the voltage to direct current (DC) to charge a battery. Other devices, such as computers and printers, may be equipped with external switches to allow the use of different power sources. However, few if any portable power tools have been designed with such a switch, and corded tools have no transformer. So before packing away your favorite power saw for work in another country, be sure that there is a power supply in place that can support the tool's required voltage and frequency.

1.3.3 Impact Drivers

Impact drivers (*Figure 14*) are usually lighter and more compact than common power drills and hammer drills. They also apply more torque when fastening screws or bolts. As a result, impact drivers are excellent tools for driving (or loosening) large numbers of fasteners, screws, nuts, or lag bolts. They are also a good choice when working on harder surfaces such as pressure-treated lumber, hardwoods, or even steel. Unlike most power drills, they typically do not offer variable speeds, which makes impact drivers less suited for jobs requiring precision or detailed work.

Another more subtle difference between hammer drills and impact drivers is the way they function. Hammer drills exert downward, pounding force on the bit while the chuck is turning. Impact drivers use a spring to exert perpendicular force on the bit. When the bit detects resistance as it turns, the driver exerts greater force, called **torque**, on the turning bit. Torque is the force produced by the drill as it turns the bit.

Finally, impact drivers have a hexagonal-shaped collet, or clamp, instead of a chuck. The hexagonal design is needed because of the extra torque exerted on the bit by the impact driver.

CAUTION

Impact drivers generate much more torque than regular drills. As a result, they can split, break, or rip through softer or more brittle surfaces. Be extra careful when using an impact driver to attach fasteners to wood or softer materials.

Torque: The turning force produced by the drill. As the bit's turning speed increases, torque decreases, and vice versa.

1.3.4 Impact Driver Safety and Maintenance

In addition to following basic power tool safety guidelines, familiarize yourself with these impact drill safety rules before operating the tool:

- Always wear the appropriate PPE when working with impact drivers.
- Read and understand the manufacturer's manual.
- Clean the impact driver before using it.
- Ensure the proper accessory is used for the job.
- Confirm that the fastener and material you are drilling into will not be damaged by the torque generated by the impact driver.

Figure 14 Impact driver.
Source: Image property of Stanley Black & Decker. Used with permission

1.3.5 Operating Impact Drivers

Use the following steps to operate an impact driver:

Step 1 Don the appropriate PPE.
Step 2 Select the appropriate bit or attachment for the job.
Step 3 Disconnect the driver from its power source.
Step 4 Pull the collet forward and insert the bit. Once the collet snaps back in place, the bit is attached.
Step 5 Reconnect the driver to its power source.
Step 6 Set the direction you want the bit to turn (tighten or loosen).
Step 7 Place the bit or socket squarely on the fastener.
Step 8 Start the tool slowly and release the trigger when the fastener is attached or removed. Driving the fastener too hard can damage it.

1.4.0 Pneumatic Drills and Impact Wrenches

Pneumatic tools are powered by compressed air. An air hose transfers the compressed air from an air compressor to the tool. Pneumatic tools tend to have more power for their weight than comparable electric tools. Two common pneumatic power tools used by construction workers are pneumatic drills and impact wrenches.

1.4.1 Pneumatic Drills

Pneumatic drills have many of the same parts, controls, and applications as electric drills. Since there is no motor, they are generally more compact in size. These drills are typically used when there is no available source of electricity, or when a high rate of production is necessary. Like electric drills, they can be used as power screwdrivers when fitted with the proper attachments. The pneumatic drill in *Figure 15* has a keyless chuck. They are also equipped with keyed chucks.

Common sizes of pneumatic drills are ¼-, ⅜-, and ½-inch. The size refers to the diameter of the largest bit shank that can be gripped in the chuck, not the drilling capacity. Some common metric sizes are 8 mm, 10 mm, and 13 mm.

1.4.2 Impact Wrenches

Impact wrenches are available in pneumatic (*Figure 16*) and electric (corded and cordless) (*Figure 17*) models. Both types are used to fasten, tighten, and loosen nuts and bolts. Like pneumatic drills, pneumatic impact wrenches must be connected with a hose to an air compressor. The speed and torque of these wrenches can be adjusted based on requirements of the job. Electric models lack the strength of pneumatic wrenches, but they are easier to maintain, especially since there is no need to service hoses and compressors.

While pneumatic impact wrenches have traditionally been more popular than their electric cousins, advances in battery-powered technology make cordless wrenches a more viable option today. Some of the most advanced cordless impact wrenches can generate up to 1,500 ft-lbs of breakaway torque.

Figure 15 Pneumatic drill.
Source: Image property of Stanley Black & Decker. Used with permission

Figure 16 Pneumatic impact wrench.
Source: Courtesy of Atlas Copco

Figure 17 Cordless impact wrench.
Source: Image property of Stanley Black & Decker. Used with permission

Although this is nowhere near the forward torque available on some larger pneumatic wrenches, it still provides a convenient and strong alternative for smaller jobs.

1.4.3 Pneumatic Tool Safety and Maintenance Guidelines

In addition to following basic power tool safety guidelines, familiarize yourself with the following pneumatic drill and impact wrench safety rules before operating either type of tool:

- Always wear the appropriate PPE, including eye, hand, and ear protection.
- Review the manufacturer's instructions provided with the pneumatic tool.
- Before changing attachments or performing any maintenance on a pneumatic drill or impact wrench, make sure the air supply is turned off and the tool is physically disconnected from the supply hose.
- Make sure that the workpiece is secure and always maintain a balanced body stance when operating the tool.
- Regularly check the air hose for damage.
- Keep your hands away from the working end of the tool.
- If you are using a pneumatic wrench to tighten a bolt-and-nut combination, use a backup wrench to keep the bolt or nut from spinning.
- Confirm the air supply is clean, dry, and at the proper pressure.
- Keep the drill or wrench lubricated.
- Use only those drill bits and impact sockets that are designed for use with the tool.

WARNING!

The amount of air pressure used to power a pneumatic drill is higher than the OSHA recommendation for cleaning a work area or similar activities. Improper use of pressurized air can lead to injuries as well as damage to the tool or materials.

1.4.4 Operating Pneumatic Drills and Impact Wrenches

Use the following steps to operate a pneumatic drill or impact wrench:

Step 1 Don the appropriate PPE.

Step 2 Prior to operating the pneumatic drill or impact wrench, ensure there is an oiler if the tool requires one, either at the air source or at the tool (*Figure 18*). Confirm the oiler is set properly.

Step 3 Attach the appropriate bit or socket to the tool.

Step 4 Make sure the pneumatic connection between the tool and the supply hose is secure, and install a whip check as required (*Figure 19*). A **whip check** is a safety attachment used to prevent whiplashing in hoses that are inadvertently uncoupled.

Whip check: A safety attachment used to prevent whiplashing in hoses when they are inadvertently uncoupled.

WARNING!

The air hose must be connected properly and securely. An unsecured air hose can come loose and whip around violently, causing serious injury. Some fittings require the use of whip checks to keep them from coming loose.

Step 5 Confirm the compressor's regulator is set to the appropriate PSI. Also, if tightening a bolt or nut, check the recommended torque specifications prior to using the tool.

WARNING!

Use only impact sockets made for pneumatic impact wrenches. Using handheld sockets can damage property and cause injury.

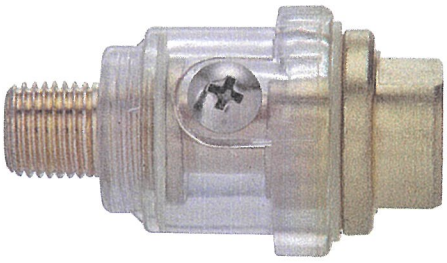


Figure 18 Inline pneumatic oiler reservoir.
Source: C. R. Laurence Co.

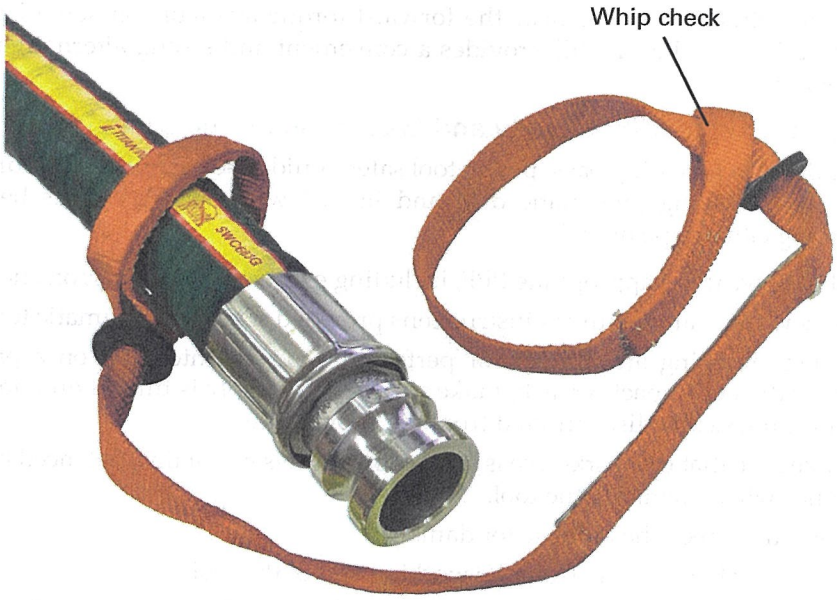


Figure 19 Connect the pneumatic tool and hose using the whip check.
Source: Capital Rubber Corporation. Used with permission

Step 6 Grip the drill or wrench firmly before operating the tool.
Step 7 When you finish using the tool, disconnect it from the air hose.

1.0.0 Section Review

1. The trigger lock on power tools should never be used to lock the trigger in the On position.
   a. True
   b. False
2. The part on a power drill that enables a user to back out a drill bit when it is stuck in the work material is called a(n) _____.
   a. chuck key
   b. reversing switch
   c. whip check
   d. auger switch
3. An important difference between hammer drills and rotary hammers is _____.
   a. rotary hammers turn faster
   b. hammer drills are designed for heavy duty jobs
   c. rotary hammers have keyed chucks
   d. rotary hammers have specially designed chucks
4. A pneumatic power tool that is best suited for fastening, tightening, and loosening nuts and bolts is a _____.
   a. cordless screwdriver
   b. hydraulic ratchet
   c. pneumatic impact wrench
   d. right-angle drill

2.0.0 Power Saws

Objective

Identify and explain how to use various types of power saws.

a. Explain how to use a circular saw and identify different types of blades.
b. Differentiate between jigsaws and reciprocating saws and explain how to use them.
c. Explain how to use a portable band saw.
d. Describe the difference between miter saws and cutoff saws.
e. Explain how to use table saws and describe the types of jobs for which they are best suited.

Performance Task

1. Safely and properly demonstrate the use of the following tools:
   - Circular saw
   - Jigsaw or reciprocating saw
   - Portable band saw
   - Miter or cutoff saw
   - Table saw

Using the right saw for the job will make your work much easier. Always make sure that the blade is right for the material being cut. This section focuses on the following types of power saws:

- Circular saws
- Jigsaw and reciprocating saws
- Portable handheld band saws
- Power miter saws
- Table saws

2.1.0 Circular Saws

Many years ago, a company named Skil® made power tool history by introducing the portable circular saw. Today, many companies make dozens of models, but a lot of people still refer to portable circular saws as Skilsaws. Other names include utility saw, electric handsaw, and builder's saw. The portable circular saw (*Figure 20*) is designed to cut lumber and boards to size and they are available in corded and cordless models.

The size of a circular saw is based on the diameter of the circular blade. Circular saws used in the United States typically use fractional-inch measurements with blade diameters that range from 3⅜ to 16¼ inches. The most popular blade size for corded saws is 7¼ inches. Many smaller cordless circular saws use a 6½-inch blade. The hole in the center of a circular saw blade fits onto the **arbor**, or shaft, of the saw. The most common arbor size for a circular saw blade is ⅝ inch.

Arbor: The end of a circular saw shaft where the blade is mounted.

Circular saws are also available in metric sizes. Metric circular saws typically have circular blades of 165 mm, 190 mm, or 235 mm. Most metric circular saws have a 20 mm arbor, although some have a 25.4 mm arbor. It is important to note that standard saws with fractional-inch measurements are not interchangeable with metric saws. For instance, a 7¼-inch blade with a ⅝-inch arbor hole is not the same as a 190 mm blade with a 20 mm arbor hole. Only metric blades can be used on metric saws and only fractional-inch blades can be used on standard saws.

Circular saw weights can vary, but most of them weigh between 7 and 14 pounds (3.175 kg and 6.35 kg). The handle of the circular saw has a trigger switch that starts the saw. The motor is protected by a rigid housing. Blade speed when the blade is not engaged in cutting is stated in rpm. The teeth of the blade point in the direction of rotation.

The blade is protected by two guards. On top, the upper blade guard protects workers from flying debris and from accidentally touching the spinning blade. The lower guard is spring-loaded; when the saw is pushed forward, it retracts up and under the top guard to allow the saw to cut.

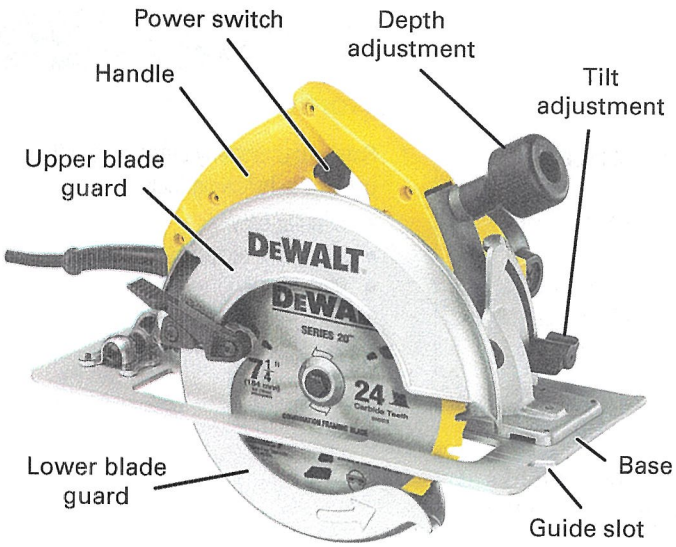


Figure 20 Portable circular saw.
Source: Image property of Stanley Black & Decker. Used with permission

Figure 21 Circular saw blades.
Source: Image property of Stanley Black & Decker. Used with permission

WARNING!

Never use a saw unless the lower blade guard is properly attached. The top guard protects the user from the blade and from flying particles.

Saw blades fall into two categories: standard steel and carbide-tipped. Standard steel blades must be sharpened regularly while carbide-tipped blades remain sharp for a much longer period of time. When using carbide-tipped blades, however, it is important to select the right blade for the job. *Figure 21* shows some of the most common types of saw blades, including the following:

- *Rip* — These blades are designed to cut with the grain of the wood. The square chisel teeth cut parallel with the grain and are generally larger than other types of blade teeth.
- *Crosscut* — These blades are designed to cut across the grain of the wood; that is, at 90-degree angle. Crosscut teeth cut at an angle and are finer than rip blade teeth.
- *Combination* — These blades are designed to cut hard or soft wood, either with or across the grain. The combination blade features both rip and cross-cut teeth with deep troughs (gullets) between the teeth.
- *Nail cutter* — This blade has large carbide-tipped teeth that can make rough cuts through nails that may be embedded in the work.
- *Nonferrous metal cutter* — This blade has carbide-tipped teeth for cutting aluminum, copper, lead, and brass. It should be lubricated with oil or wax before each use.

Always follow the manufacturer's instructions when using saw blades.

2.1.1 Circular Saw Safety Guidelines and Maintenance

There are numerous factors to consider in order to use a circular saw safely and effectively. In addition to following basic power tool safety guidelines, familiarize yourself with the following circular saw safety rules before operation:

- Always wear the appropriate PPE when working with saws, especially safety glasses.
- Always be aware of the blade's location as it relates to your hands or any other part of your body.

- Before connecting the saw to its source of power, ensure that the blade is tight and that the blade guard is working correctly. The chosen blade should have a maximum rpm equal to or higher than the speed of the saw.
- To avoid hitting water lines or electrical wiring, find out what is inside the wall or on the other side of a partition before cutting through a structure.
- During operation, keep both hands on the saw grips.
- Never force the saw through the work. This causes binding and overheating and may cause injury.
- Never reach underneath the work while operating the saw and never stand directly behind the work.
- Always stand to one side of the work.
- Use clamps to secure small pieces of material to be cut.
- Know where the saw's power cord is located at all times. Accidentally cutting through the power cord can cause electrocution.

WARNING!

When using a circular saw, workers should never hold material to be cut with their hands; always use a clamp instead.

The most important maintenance on a circular saw is at the lower blade guard. Sawdust builds up and causes the guard to stick. If the guard sticks and does not move quickly over the blade after it makes a cut, the bare blade may still be turning when the saw is set down and may cause damage. Remove sawdust from the blade guard area. Remember to always disconnect the power source before performing any maintenance. To avoid personal injury and damage to materials, check often to make sure the guard snaps shut quickly and smoothly. To ensure smooth operation of the guard, disconnect the saw from its power source, allow it to cool, and clean foreign material from the track. Be aware of fire hazards when using cleaning liquids such as isopropyl alcohol. Do not lubricate the guard with oil or grease. This could cause sawdust to stick in the mechanism. Always keep blades clean and sharp to reduce friction and kickback. Blades can be cleaned with hot water or mineral spirits. Be careful with mineral spirits as they are very flammable.

2.1.2 Operating Circular Saws

Use the following steps to operate a circular saw:

Step 1 Don the appropriate PPE.

Step 2 Secure and support the material you are cutting. If the work isn't heavy enough to stay in position without moving, it should be weighted or clamped down.

Step 3 Mark the cut using a pencil or marking tool.

Step 4 Unplug or remove the battery pack from the saw before adjusting the blade depth to the thickness of the wood being cut plus ¼-inch (≈6 mm). This prevents the blade from protruding through the material farther than necessary.

Step 5 Place the front edge of the baseplate on the work so the guide notch and the blade are in line.

Step 6 After the saw has been started and is up to full speed, slowly move it forward to begin cutting. As the blade begins to cut, it will leave a **kerf** (*Figure* 22) that measures roughly ⅛-inch (3.2 mm) wide. It is important to consider the width of the kerf when making a cut with a circular saw. Be sure to align the blade with the waste side of the cutting line, or the finished piece will be short. When marking for the cut, mark an X on the waste side of the cut mark as a reminder of which side of the mark to cut.

CAUTION

Make sure the blade is appropriate for the material being cut.

Kerf: The channel created by a saw blade passing through the material, which is equal to the width of the blade teeth.

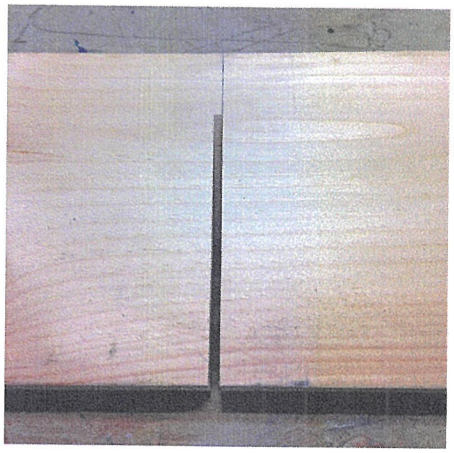


Figure 22 Saw kerf.
Source: Cianbro Corporation

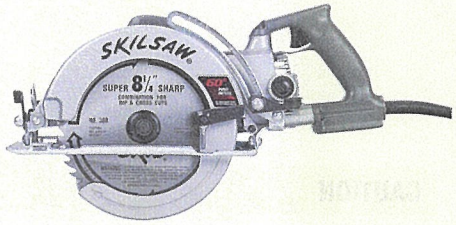
Figure 23 Proper use of a circular saw.

NOTE

If the saw cuts off the line, stop the saw, back up slightly, and restart the cut. Do not force the saw.

Step 7 The lower blade guard will automatically rotate up and under the top guard when the saw is pushed forward. While cutting with the saw, grip the saw handles firmly with two hands, as shown in *Figure 23*. As the cut nears completion, the guide notch on the baseplate will move off the end of the work. At that point, use the blade as a guide.

Step 8 Release the trigger switch once the cut is complete. The blade will stop rotating. Make sure the blade has stopped before setting the saw down.



Source: Robert Bosch Tool Corporation

The Worm-Drive Saw

The worm-drive saw is a heavy-duty type of circular saw. Most circular saws have a direct drive. That is, the blade is mounted on a shaft that is part of the motor. With a worm-drive saw, the motor drives the blade from the rear through two gears. One gear (the worm gear) is cylindrical and threaded like a screw. The worm gear drives a wheel-shaped gear (the worm wheel) that is directly attached to the shaft to which the blade is fastened. This setup delivers much more rotational force (torque), making it easier to cut a double thickness of lumber. The worm-drive saw is almost twice as heavy as a conventional circular saw, and should be used only by an experienced craftworker.

2.2.0 Jigsaws and Reciprocating Saws

Reciprocating: Moving backward and forward on a straight line.

The two types of saws capable of making straight and curved cuts are jigsaws and **reciprocating** saws. Both of these saws have a blade that moves back and forth to enable the cutting action.

2.2.1 Jigsaws

Jigsaws have very fine blades, which makes them effective tools for doing delicate and intricate work. They are commonly used for cutting out patterns or irregular shapes from wood or even thin metals.

Today's cordless jigsaw (*Figure 24*) is an extremely useful portable power tool. It can make straight or curved cuts in wood, metal, plastic, wallboard,

and other materials. The jigsaw cuts with a blade that moves up and down, unlike the spinning blade of a circular saw. This means that each cutting stroke (upward) is followed by a return stroke (downward), so the saw is cutting only half the time it is operating. This is called up-cutting or clean-cutting.

An important part of the jigsaw is the baseplate (shoeplate or footplate). Its broad surface helps to keep the blade lined up. It keeps the work from vibrating and allows the blade teeth to bite into the material.

Many models are available with tilting baseplates for cutting beveled edges. Models come with a top handle or a barrel handle. Some cordless models are available.

The jigsaw has changeable blades that enable it to cut many different materials, from wood and metal to wallboard and ceramic tile. Fine-toothed blades are used for thin materials and smoother cuts. Coarse blades are used for faster cutting of thicker materials and when smooth cuts are not a concern. Blades are rated by the number of teeth per inch or teeth per centimeter.

Most jigsaws can be operated at various blade speeds. Types of jigsaws include single-speed, two-speed, and variable-speed. The speed of a variable-speed jigsaw is controlled by how far the trigger is depressed. The low-speed range is for cutting hard materials, and the high-speed range is for soft materials.

Figure 24 Jigsaws.
Source: Image property of Stanley Black & Decker. Used with permission

CAUTION

Do not lift the blade out of the work while the saw is still running. If the blade is lifted out, the tip of the blade may hit the wood surface, marring the work and possibly breaking the blade.

2.2.2 Reciprocating Saws

A reciprocating saw, regardless of the manufacturer, is often referred to as a SawZall® (a trademark of the Milwaukee Electric Tool Corporation) in the United States because it was the first saw designed to serve as an electric hacksaw. Both the jigsaw and the reciprocating saw can make straight and curved cuts. They are used to cut irregular shapes and holes in plaster, plasterboard, plywood, studs, metal, and most other materials that can be cut with a saw.

Both saws have straight blades that move up and down along a straight line as they are guided along the cut. The reciprocating saw (*Figure 25*) is designed for more heavy-duty jobs than the jigsaw. It also uses longer and tougher blades than a jigsaw. In fact, the reciprocating saw is used for jobs that require brute strength, which makes it an excellent choice for general demolition work. It can saw through walls or ceilings and create openings for windows, plumbing lines, and more.

Jigsaw and reciprocating saw blades are available for a wide variety of cutting tasks and materials. To make selection easier, the blades are often labeled for the material or specific use. As a general rule, metal-cutting blades have more teeth per inch (or per centimeter) than wood-cutting blades. The teeth are also smaller.

Like the jigsaw, reciprocating saws come in single-speed, two-speed, and variable-speed models. The low-speed setting is best for metal work. The high-speed setting is for sawing wood and other soft materials.

The baseplate (shoeplate or footplate) may have a swiveling action, or it may be fixed. Whatever the design, the baseplate is there to provide a brace or support point for the sawing operation.

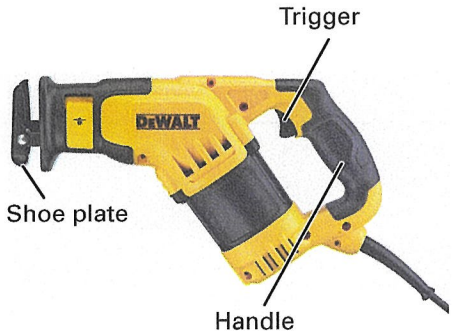


Figure 25 Reciprocating saw.
Source: Image property of Stanley Black & Decker. Used with permission

2.2.3 Jigsaw and Reciprocating Saw Safety and Maintenance

As with any power tool, jigsaws and reciprocating saws can be dangerous to operate if safety guidelines are ignored. In addition to following basic power tool safety guidelines, familiarize yourself with the following safety rules before operating a jigsaw or reciprocating saw:

- Always wear the appropriate PPE when working with saws, especially safety glasses.
- Before cutting through a wall or partition, find out what is inside the wall or on the other side of the partition. This will prevent the accidental cutting of water lines or electrical wiring.

Figure 26 Proper use of a reciprocating saw.
Source: Image property of Stanley Black & Decker. Used with permission

- Make sure that the saw is disconnected from its power source before installing or changing blades, or performing any maintenance on the saw.
- When installing a blade in the saw, make sure it is in the collar as far as it will go before tightening the setscrew securely.
- When replacing a broken blade, look for any pieces of the blade that may be stuck inside the collar.
- Verify that the switch is in the Off position before it is plugged into a power source.
- Always use a sharp blade and never force the blade through the work. Forcing or leaning into the blade can cause you to lose balance, and possibly even be cut by the saw.
- When cutting metal, use a metal-cutting blade.
- Lubricate the blade with an agent such as beeswax, to help make tight turns and to reduce the chance of breaking the blade.

2.2.4 Operating Jigsaws and Reciprocating Saws

Many of the steps involved in the safe and efficient use of jigsaws and reciprocating saws are the same. Use the following steps to operate both types of saws:

Step 1 Don the appropriate PPE.
Step 2 Clamp the material being sawed to a pair of sawhorses or secure it in a vise to reduce vibration.
Step 3 Disconnect the saw from its power source.
Step 4 Confirm that the blade you have chosen is suited for the material you are cutting.
Step 5 Check the blade for dulling or damage.
Step 6 Measure the material and mark it before cutting.
Step 7 If a cut must be made from the middle of a board, drill a hole at the starting point that is large enough to allow the blade to pass through.
Step 8 Reconnect the saw to its power source.
Step 9 Squeeze the trigger to start the saw and move the blade gently but firmly into the material. Continue feeding the saw into the work at a reasonable pace without forcing it. Never force the blade into the work.
Step 10 When the cut is finished, release the trigger and let the blade come to a stop *before* removing it from the work.

NOTE

If cutting from the edge of a board or panel with a jigsaw, ensure the front of the baseplate is resting firmly on the surface of the work before starting the saw. The blade should not be touching the work at this stage.

NOTE

When a reciprocating saw blade first strikes a surface, it may jump back. Keep a steady hand, and the cutting action will eventually allow the blade to enter the workpiece. Forcefully plunging the blade into the surface is a common cause of broken blades.

Before cutting material with a reciprocating saw, set the saw to the desired speed. Use lower speeds for sawing metal; use higher speeds for sawing wood and other soft materials. Grip the saw with both hands (*Figure 26*) and place the baseplate firmly against the workpiece. Once the trigger is squeezed, the blade moves back and forth, cutting the material on the backstroke.

WARNING!

Use both hands to firmly grip the reciprocating saw. Otherwise, the pull created by the blade's grip may jerk the saw out of your grasp.

2.3.0 Portable Band Saws

The portable band saw (*Figure 27*) can cut pipe, metal, plastics, wood, and irregularly shaped materials. It is especially good for cutting heavy metal, but performs equally as well on fine cutting jobs. Although it can cut wood, it is used almost exclusively to cut metal products on the job site.

The band saw has a one-piece blade that runs in one direction around guides at either end of the saw. The blade is a thin, flat piece of steel that must be of the proper length to fit the revolving pulleys that drive and support it. Proper

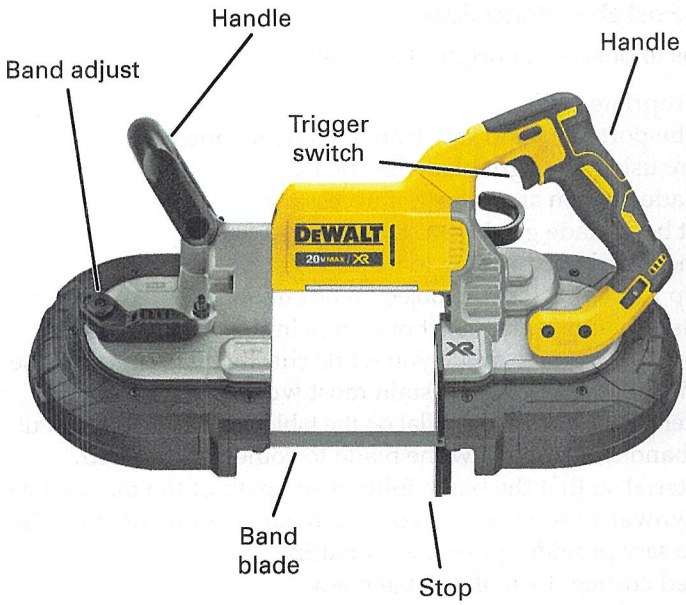


Figure 27 Portable handheld band saw.
Source: Image property of Stanley Black & Decker. Used with permission

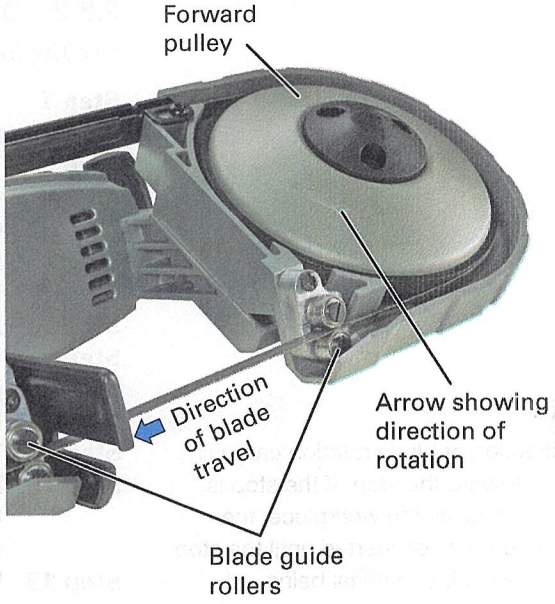


Figure 28 Band saw pulley and blade guide rollers.
Source: Courtesy of Milwaukee Electric Tool Corporation

blade length is determined by referencing the manufacturer's documentation. Like most blades, its coarseness is rated in teeth per centimeter or teeth per inch (TPI). As a general rule, higher TPIs produce smoother cuts. Thicker materials require coarser blades. However, if the blade is too coarse for the material, the individual teeth may begin to break off. *Figure 28* shows how the blade is routed around the pulleys and through the blade guides.

While some band saws have multiple speeds, most do not. The portable band saw generally cuts best at a low speed since higher speeds cause the blade's teeth to rub rather than cut. This can create heat through friction, which reduces the life of the blade.

WARNING!

A portable band saw always cuts in the direction of the user. For that reason, workers must be especially careful to avoid injury when using this type of saw. Always wear appropriate PPE and stay focused on the work.

2.3.1 Band Saw Safety and Maintenance

In addition to following basic power tool safety guidelines, familiarize yourself with the following band saw safety rules before operation:

- Always wear the appropriate PPE when working with saws, especially safety glasses.
- Keep your hands and fingers away from the path of the blade.
- Make sure the saw is disconnected from its power source before performing any maintenance or before adjusting the blade.
- Never use your thumbs to move wood or other materials toward the blade.
- Use only a band saw that has a stop in place.
- Before cutting through lines or pipes, confirm that they do not contain hazardous or combustible materials.
- Never force a portable band saw; let the saw do the cutting.
- Before backing out of a cut, turn off the machine, then back out the blade after it stops moving.

2.3.2 Operating a Portable Band Saw

Use the following steps to operate a portable band saw:

Step 1 Don the appropriate PPE.
Step 2 Disconnect the portable band saw from its power source.
Step 3 Verify you are using the right blade for the job.
Step 4 Check the blade tension and adjust, if necessary.
Step 5 Confirm that both blade guides are close to the blade.
Step 6 Reconnect the portable band saw to its power source.
Step 7 Place the stop firmly against the object to be cut.
Step 8 Plan saw cuts to avoid backing out of curves in the object being cut.
Step 9 Place marks on the wood to guide you while cutting. Remember to use pencil since ink will permanently stain most woods.
Step 10 Hold the material you intend to cut flat on the table before starting the cut.
Step 11 Turn on the band saw and allow the blade to come to full speed.
Step 12 Feed the material so that the blade follows the path of the marks. Little or no downward pressure is needed to make a good cut since the weight of the saw provides pressure for cutting.
Step 13 When finished cutting, turn off the bandsaw.

NOTE

The direction of blade rotation can pull the saw toward the stop. If the stop is not firmly against the workpiece, the saw will jump when started until the stop slams against the material being cut.

2.4.0 Miter and Cutoff Saws

Miter saws and cutoff saws are similar in that both are used to make straight or miter cuts. Both types of saws can be mounted permanently, but portable and cordless versions of the saws have the convenience of allowing users to move them from a workshop to a work site.

2.4.1 Power Miter Saws

The power miter saw combines a miter box with a circular saw, allowing it to make straight and miter cuts. There are two types of power miter saws: power miter saws and compound miter saws.

The saw blade of a standard miter saw pivots horizontally from the rear of the table and locks in position to cut angles from 0 to 45 degrees right and left. Stops are preset for common angles. The difference between the power miter saw and the compound miter saw (*Figure 29A*) is that the blade on the compound miter saw can be tilted vertically, allowing the saw to be used to make a compound cut (combined bevel and miter cut).

Similar to a miter saw and compound miter saw is the compound-slide miter saw (*Figure 29B*). A compound-slide miter saw has a rail in the table that allows the motor and blade assembly to slide forward and backward. This sliding capability enables the tool to cut wider material than a standard miter saw can cut.

(A) Compound Miter Saw **(B) Compound Sliding Miter Saw**

Figure 29 Miter saws.
Source: Makita USA, Inc. (29A); Image property of Stanley Black & Decker. Used with permission (29B)

2.4.2 Abrasive Cutoff Saws

An abrasive cutoff saw (*Figure 30*), also referred to as a *chop saw* or *cutoff saw*, can be used to make straight cuts or angular cuts through materials such as angle iron, flat bar, and channel. Like miter saws, cutoff saws can be either stationary or portable.

The abrasive blade on a cutoff saw can be between 10 and 18 inches in diameter. Metric blades are commonly 250 mm to 350 mm in diameter. When the saw is in operation, the blade spins at such a high speed that the resulting friction is hot enough to burn through the material. Like all rotating blades and stones, the maximum rpm of the blade must be equal to or greater than that of the saw.

Figure 30 Abrasive cutoff saw.
Source: Image property of Stanley Black & Decker. Used with permission

2.4.3 Miter and Cutoff Saw Safety and Maintenance

Several basic safety guidelines should be followed when operating a miter saw or a cutoff saw to ensure worker safety and equipment protection. If either saw is being used on materials that produce airborne dust, there are important silica exposure standards that must be followed. Silica exposure standards are outlined in the NCCER Module 00101, *Basic Safety*.

In addition to following basic power tool safety guidelines, familiarize yourself with the following safety rules before operating a miter or cutoff saw:

- Always wear the appropriate PPE when working with saws, especially safety glasses.
- Never wear a watch or jewelry while operating the saw because they can get caught in the machinery.
- Securely lock the blade at the correct cutting angle.
- While operating the saw, keep your hands and fingers clear of the blade and never attempt to adjust the saw while it is running.
- Confirm the blade is in good condition and secure before using the saw.
- Do not allow other workers to stand nearby while operating a saw.
- Make sure the work area is clear of flammable materials such as chemicals and rags that could ignite from sparks. Abrasive cutoff saws tend to produce streams of sparks.
- Disconnect the saw from its power source before changing the blade or performing any sort of maintenance or setup.
- Verify that the rpm rating of the blade meets or exceeds the saw's spindle speed.
- Check all saw guards to ensure they are in place and working properly.
- Never retract a safety guard to view the material being cut while the saw is in use.
- If cutting long material, ensure the other end of the material is supported.

2.4.4 Operating Miter and Cutoff Saws

Using a power miter saw and an abrasive cutoff saw safely and efficiently involves many of the same steps used for other types of power saws. Use the following steps to operate a power miter or cutoff saw:

Step 1 Don the appropriate PPE.
Step 2 Ensure the power supply is disconnected from the saw.
Step 3 Set the angle or tilt of the blade according to the cut that needs to be made.
Step 4 Reconnect the power supply to saw.
Step 5 Place the material to be cut firmly against the fence.
Step 6 With the blade arm raised, turn on the saw and allow it to reach maximum speed.
Step 7 Firmly grasp the handle of the rotating saw arm and lower the blade on to the material. Some compound miters allow the rotating arm to slide while cutting.
Step 8 Once the cut has been made, turn off the saw and raise the rotating saw arm.

2.5.0 Table Saws

Table saws are designed with a circular saw blade that protrudes up through a slot on the bench. They are typically distinguished by the size blade they can accommodate. Table saws using 10-inch blades are excellent options for most carpentry jobs, while saws with 8-inch blades are designed for cutting smaller materials. Those with 12-inch blades are the best choice for larger jobs.

Table saws are typically used for ripping and crosscutting lumber. Ripping involves cutting lumber to a specific width while crosscutting involves cutting it to a specific length. Since the table saw has an exposed blade and a fence, users can feed lumber into the blade in a controlled manner. The result is a saw that is excellent for making precise and accurate cuts, which is one reason table saws are a favorite of furniture and cabinet makers.

While many older table saws were large, stationary tables that plugged into a receptacle for power, many of today's table saws are cordless and/or portable with folding legs (*Figure 31*).

The table part of this tool is where wood is laid before it is pushed against the rip fence and into the saw blade. The saw part of this tool is mounted under the table and can be adjusted up and down to expose more or less of the blade. Some table saws also allow the blade to be tilted up to 45 degrees.

2.5.1 Table Saw Safety and Maintenance

In addition to following basic power tool safety guidelines, familiarize yourself with the following table saw safety rules before operating it:

- Always wear the appropriate PPE when working with saws, especially safety glasses.
- Use blades designed for the job.
- Confirm the blade is sharp prior to cutting.
- Verify that the blade guard moves freely before connecting the power.
- Use a push stick or board to push any material that may require your hand to pass near the blade.
- Do not use the table saw fence during a crosscutting operation without placing a block between the material being cut and the fence. This prevents the cutoff piece from being trapped between the blade and the fence.
- Keep the table saw bench clear of all debris, especially when it is in use.
- Disconnect the table saw from its power source when you are adjusting the blade or performing any type of maintenance.
- Always anticipate kickback when ripping any type of material. This means you should not stand in line with the blade while it is cutting. Instead, stand to one side until cutting is finished.
- Set the blade to the correct height.
- Make sure any lumber you are cutting is flat on the bench and the board is pressed level against the rip fence when cutting. Otherwise, binding and kickback may occur.

Figure 31 Portable table saw.
Source: Image property of Stanley Black & Decker. Used with permission

2.5.2 Ripping Wood with a Table Saw

Use the following steps to rip wood or another material on a table saw:

Step 1 Don the appropriate PPE.
Step 2 Confirm the table saw is disconnected from any power source.
Step 3 Ensure the table saw is fitted with a rip blade.

Step 4 Adjust the blade so that it is no more than ¼-inch above the thickness of the material to be cut.

Step 5 Adjust the rip fence so that its inner edge corresponds with the desired width of the material once it is cut.

Step 6 Connect the power source and place the material you want to cut on the bench. Make sure it is aligned against the rip fence, but not touching the blade.

Step 7 Slowly push the material along the edge of the rip fence, making sure the material is held snugly against the rip fence while it is pushed.

Step 8 Use a push stick to guide the final few inches of the material past the blade. Push sticks should always be used if there is any chance that pushing the material will put your fingers within a few inches of the blade.

Step 9 When finished ripping, turn off the table saw.

CAUTION

Do not push lumber or any other material against the table saw's blade before the blade reaches full speed. Contacting the blade any earlier may cause kickback and/or serious injury.

2.0.0 Section Review

1. The proper way to start cutting material with a circular saw is to _____.
   a. power up the saw to full speed then slowly move it forward into the material
   b. hold the lower blade guard up to position the blade on the cut mark
   c. press the blade against the material being cut and set the saw rpm to Low
   d. tilt the front edge of the baseplate upward and push the saw forward

2. A jigsaw is an effective tool for _____.
   a. drilling holes in concrete or pavement
   b. making long straight cuts through thick metal
   c. cutting through walls in demolition jobs
   d. doing delicate work on thin materials

3. The blade on a portable band saw _____.
   a. moves up and down through a shoeplate
   b. spins in a circular motion on an arbor
   c. runs in one direction around guides
   d. reciprocates in and out from a guard

4. A type of miter saw in which the blade can be pivoted horizontally and vertically is called a _____.
   a. sliding jigsaw
   b. compound miter saw
   c. reciprocating saw
   d. sliding abrasive saw

5. Pushing a board against a table saw's blade before it reaches full speed _____.
   a. is the desired approach when ripping thin lumber
   b. is the best approach when using larger blades
   c. can cause kickback and serious injury
   d. can increase efficiency and speed

3.0.0 Grinders and Oscillating Multi-Tools

Performance Task

1. Safely and properly demonstrate the use of the following tools:
   - Portable or bench grinder
   - Oscillating multi-tool

Objective

Describe the types of jobs best suited to grinders and oscillating multi-tools.

a. Explain how to use various types of grinders.
b. Identify grinder accessories and the jobs for which they are used.
c. List the type of jobs that can be performed using an oscillating multi-tool.

Abrasive: A substance, such as sandpaper, that is used to wear away material.

Grit: A granular, sand-like material used to make sandpaper and similar materials abrasive. Grit is graded according to its texture. The grit number indicates the number of abrasive granules in a standard size (per in or per cm). The higher the grit number, the more particles in a given area, indicating a finer abrasive material.

Grinding tools can power all kinds of **abrasive** wheels, brushes, buffs, drums, bits, saws, and discs. These wheels come in a variety of materials and **grit**. They can drill, cut, smooth, and polish; shape or sand wood or metal; mark steel and glass; and sharpen or engrave. They can even be used on plastics.

WARNING!

Always wear safety goggles and a face shield when working with grinders. Make sure that the work area is free of combustible materials such as rags or flammable liquids and that a fire extinguisher is easily accessible. Clothes should be snug and comfortable and free of cuffs at the wrists and ankles. Wearing excessively loose clothing on the work site can be extremely dangerous.

3.1.0 Grinders

Grinders are available in various configurations. Common handheld grinders include angle grinders (also called side grinders or right-angle grinders), end grinders, and detail grinders. Stationary grinders, called bench grinders, are permanently mounted on a work table or bench.

Angle grinders are used to grind away hard, heavy materials and to grind surfaces such as pipes, plates, or welds (*Figure 32*). The angle grinder has a rotating grinding disc set at a right angle to the motor shaft.

End grinders are sometimes called horizontal grinders or pencil grinders. These smaller grinders are used to smooth the inside of materials, such as pipe (*Figure 33*). The grinding disc on the end grinder rotates in line with the motor shaft. Grinding is also done with the outside of the grinding disc.

Like end grinders, detail grinders (*Figure 34A*), also known as *die grinders*, have an arbor that extends from the motor shaft onto which small attachments, called points, can be mounted to smooth and polish intricate metallic work. These attachments, a sample of which is shown in *Figure 34B*, are commonly made in shaft sizes ranging from 1/16- to 1/4-inch. The shaft of these

(A) 4-inch

(B) 7-inch

Figure 32 Angle grinders.
Source: Image property of Stanley Black & Decker. Used with permission (32A–32B)

Figure 33 End grinder.
Source: Courtesy of Milwaukee Electric Tool Corporation

(A) Detail Grinder (B) Stone Cone

Figure 34 Detail grinder and point.
Source: Image property of Stanley Black & Decker. Used with permission (34A); Courtesy of Dremel (34B)

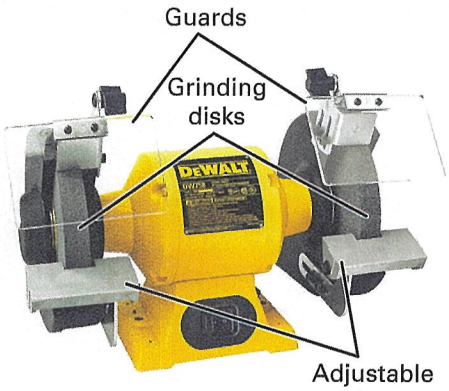


Figure 35 Bench grinder.
Source: Image property of Stanley Black & Decker. Used with permission

points is called the spindle. Metric points typically come in spindle sizes of 3 mm and 6 mm. A tremendous variety of point shapes are available to suit the grinding task.

The primary difference between an end grinder and a detail grinder is power. End grinders offer more power than a detail grinder.

Bench grinders (*Figure 35*) are electrically powered stationary grinding machines. They usually have two grinding wheels that are used for grinding, rust removal, and metal buffing. They are also great for renewing worn edges and maintaining the sharp edges of cutting tools. For example, the bench grinder can be used to smooth the mushroomed heads of cold chisels.

Heavy-duty grinder wheels range from 6¾ to 10 inches (150 mm to 250 mm) in diameter. Each wheel's maximum speed is given in rpm. Never use a grinding wheel above its rated maximum speed. Its rated speed must be equal to or faster than the maximum speed of the power tool.

Bench grinders come with an adjustable tool rest. This is the surface on which you position the material you are grinding, such as cold chisel heads. There should be a distance of only ⅛-inch (about 3 mm) between the tool rest and the wheel.

WARNING!

Never adjust tool rests when the grinder is on or when the grinding wheels are spinning. Doing so may damage the work or cause injuries. Disconnect the power source before adjusting any type of grinder.

3.1.1 Grinder Safety and Maintenance

In addition to following basic power tool safety guidelines, familiarize yourself with these safety rules before operating any type of grinder:

For Angle, End, and Detail Grinders

- Always wear the appropriate PPE when working with grinders, especially gloves and safety glasses. Wearing PPE when using grinders is critically important since grinders generate a lot of high-speed sparks and flying debris.
- Never wear loose clothing or jewelry that can get caught in a grinder's wheels.
- Always disconnect the power source before performing maintenance.
- Keep your hands away from the grinding wheel.
- To keep sparks from flying into the path of other workers or from igniting flammable materials, use standing screens when grinding near walkways, other workers, or storage areas.

- Never use an angle grinder, end grinder, or detail grinder unless it is equipped with the manufacturer-provided guard that surrounds the grinding wheel.
- Choose a grinding disc that is appropriate for the type of work being performed.
- Ensure new grinding wheel maximum rpm markings are equal to or greater than the maximum speed of the grinder before installing.
- Remember that individual wires from a wire wheel can separate from the wheel at a high rate of speed and cause injury.
- Before starting a grinder, make sure the grinding disc is properly secured and in good condition.
- Establish firm footing and maintain a firm grip on the grinder with both hands to avoid being pulled off balance.
- Let the grinder come up to full speed before grinding.
- Direct sparks and debris (*Figure 36*) away from coworkers and any flammable materials.
- When grinding on a platform, use a flame-retardant blanket to catch falling sparks.
- After shutting off the power, do not leave the tool until the grinding disc has come to a complete stop.

WARNING!

Grinding discs can instantaneously disintegrate if used when they are cracked. Inspect the disc for cracks before using the grinder.

For Bench Grinders

- Always wear the appropriate PPE when working with a bench grinder, especially gloves and safety glasses. Wearing PPE when using bench grinders is critically important since bench grinders generate a lot of high-speed sparks and flying debris.
- Grinding metal on a bench grinder creates sparks, so keep the area around the grinder clean.
- Always adjust the tool rests so they are within ⅛-inch (≈3 mm) of the wheel. This reduces the chance of getting the work wedged between the rest and the wheel.

Figure 36 Be aware of sparks created by grinders.
Source: Courtesy of Atlas Copco

- Never use a grinding wheel above its rated maximum speed.
- After finishing a job with the bench grinder, shut it off.
- Before mounting a grinding wheel onto a bench grinder, inspect the wheel for chipped edges and cracks.

WARNING!

Never grind soft metals or wood on a grinding wheel. The material will wedge itself between the grit, creating stresses that may cause the wheel to shatter.

3.1.2 Operating Grinders

Use the following steps to operate a grinder:

For Angle, End, and Detail Grinders

Step 1 Don the appropriate PPE, especially a face shield.
Step 2 Secure the material in a vise or clamp it to the workbench.
Step 3 To use an angle grinder, place one hand on the handle of the grinder and one on the trigger. To use an end grinder or detail grinder, grip the grinder handle at the shaft end with one hand and cradle the opposite (motor) end of the tool in your other hand.
Step 4 Always allow the grinder to reach its maximum speed before grinding.
Step 5 Turn off the grinder and be sure that the wheel has stopped rotating before putting it down.
Step 6 Complete the work by removing any loose material with a wire brush.

CAUTION

Do not force the tool or overload the motor. If too much pressure is applied, there will be a significant reduction in the grinder's rpm.

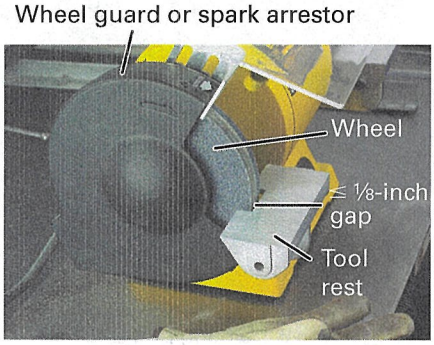
For Bench Grinders

Step 1 Don the appropriate PPE, especially a face shield.
Step 2 Always use the adjustable tool rest as a support when grinding or beveling metal pieces. There should be a maximum gap of 1/8-inch (≈3 mm) between the tool rest and the wheel and 1/4-inch (≈6 mm) between the wheel guard (also called a spark arrestor) and wheel.
Step 3 Confirm that the bench grinder is firmly secured to a stable surface.
Step 4 Always allow the grinder to reach its maximum speed before grinding.
Step 5 Keep the metal cool as it is being ground. If the metal gets too hot, it can destroy the temper (hardness) of the material.
Step 6 Always work on the face of the wheel and not on the side. *Figure 37* shows the proper way to use a bench grinder.

Did You Know?

Grinding Tungsten Can Be Hazardous to Your Grinder

Workers who use power tools are almost certain to encounter objects that contain tungsten. As mentioned earlier, tungsten is an extremely hard and brittle metal with a very high melting point. Attempting to grind tungsten carbide tools with conventional grinding discs and wheels is a bad idea. Rather than actually sharpening the tool, the most likely outcome of such an attempt is a damaged and/or weakened grinding wheel.



No more than 1/8" (≈3 mm) gap between tool rest and wheel.

Maintain a 1/4" (≈6 mm) gap between wheel and spark arrestor.

Always work on the face of the wheel.

Figure 37 Proper use of a bench grinder.
Source: Image property of Stanley Black & Decker. Used with permission

3.2.0 Grinder Attachments and Accessories

Grinders are versatile pieces of equipment. While the primary uses of a typical grinder are to grind, cut, sand, and polish materials, numerous attachments and accessories can be used to extend a grinder's capability.

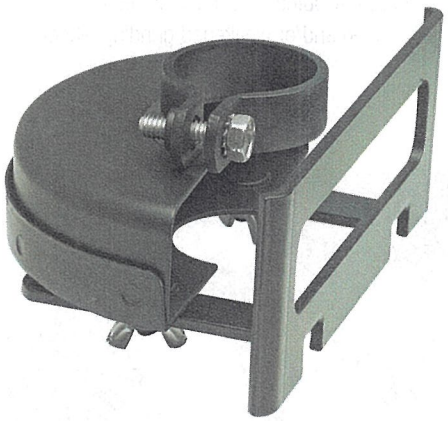
Accessories such as guards and shields (*Figure 38*) can be added to a portable grinder to provide additional protection when special grinding discs are used. For example, there are specialized guards for use with diamond discs, flap discs, and cup brushes. Side handles can be added to some grinders to improve stability and grip during use. There are also shields available to help protect against dust. Some dust shields are even equipped with a vacuum hose outlet so that dust can be vacuumed away when the grinder is in use.

Adapters and backing pads (*Figure 39*) can be installed on a grinder's arbor so that different types of sanding discs, wheels, and buffing pads can be used. The backing pad provides a stable surface for flexible discs to rest against.

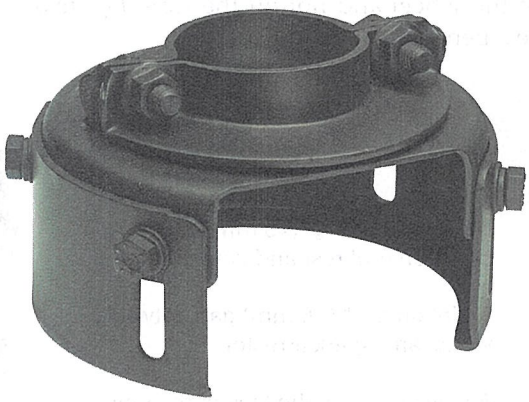
There is an almost endless variety of grinder attachments available, and most of them are available in various sizes. Some of the more common accessories are shown in *Figure 40*. They include wire brushes, cup brushes and stones, flap discs, cutting wheels, and polishing and buffing wheels. Some grinders can also be equipped with a cutoff wheel. These are best described as smaller, thinner versions of the blade used on an abrasive saw. Because of their tendency to break or fly apart when too much stress is applied, many companies require workers to have specific permission and documentation before they can be used.

Wire brushes and cup brushes are good for removing rust, scale, and file marks from metal surfaces. Flap discs are used for similar jobs, but they tend to last longer than fiber discs. Cutting discs are designed for cutting through material. Cloth buffing wheels enable a grinder to be used for polishing and buffing metal surfaces. Coring bits are sometimes used for cutting holes in stone or composite materials, such as those used for countertops.

Special bits can be used on some grinders to remove rough edges and burrs from the inside and outside of pipes and other objects. These rotary bits are commonly called burr bits (*Figure 41*). As with other grinder accessories, burr bits are available in various shapes and sizes to fit almost any need. Workers should be aware that using a grinder with a burr bit requires steady hands. These bits operate at high rpm and can catch on burrs and cause the grinder to shift around quite a bit. They can also heat up the material being smoothed and possibly damage it. It is best to work in short bursts to avoid overheating the bit and the material.



(A) Diamond Blade Guard



(B) Flaring Cup Guard

Figure 38 Grinder accessories.
Source: Image property of Stanley Black & Decker. Used with permission (38A–38B)

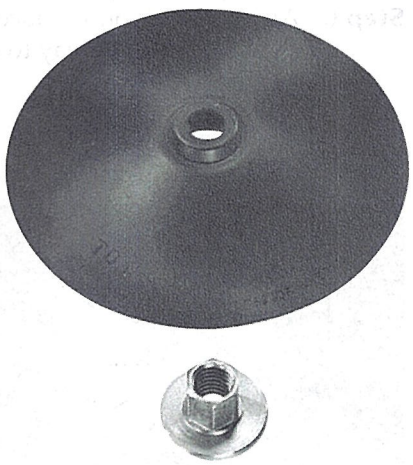
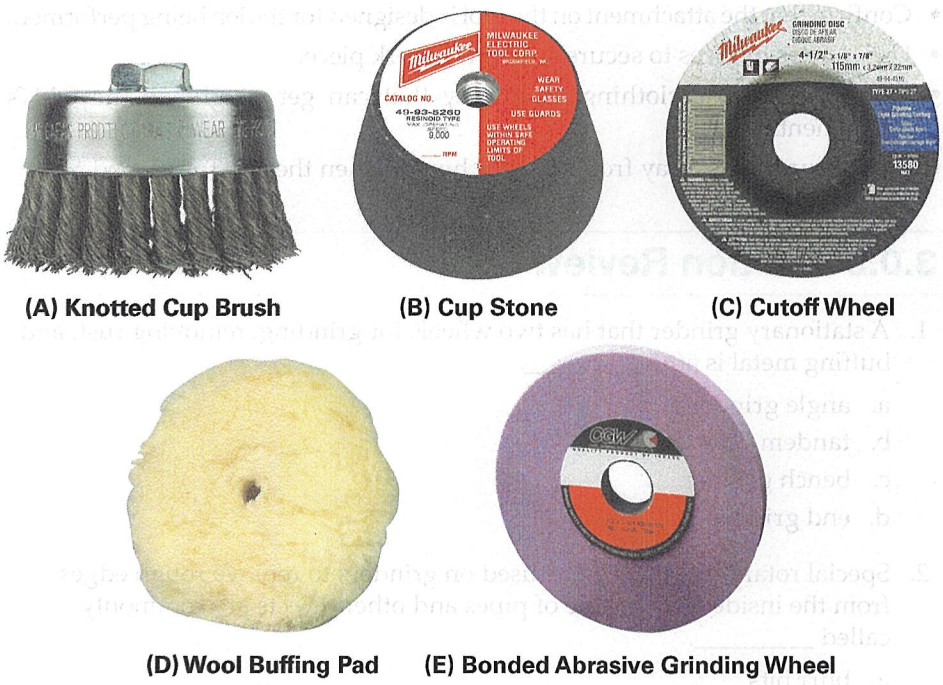


Figure 39 Backing pad and adapter nut.
Source: Image property of Stanley Black & Decker. Used with permission



(A) Knotted Cup Brush (B) Cup Stone (C) Cutoff Wheel

(D) Wool Buffing Pad (E) Bonded Abrasive Grinding Wheel

Figure 40 Grinder attachments.
Source: Courtesy of Milwaukee Electric Tool Corporation (40A–40D); Camel Grinding Wheels Works Sarid LTD (40E)

Figure 41 Burr bit assortment.
Source: Simpson Strong-Tie Company Inc.

No matter what type of attachment is used on a grinder, workers must always make sure that it is designed to fit the grinder and rated for the proper rpm. Always follow the attachment and accessory manufacturer's guidelines for use.

3.3.0 Oscillating Multi-Tools

An oscillating multi-tool (*Figure 42*), sometimes referred to as an *OMT*, looks like a handheld grinder, but the types of jobs it can perform are much more varied. This variety is the result of arbors that accept many different attachments and accessories. Oscillating multi-tools operate by moving these attachments back and forth at speeds of up to 21,000 oscillations per minute. Unlike saws or grinders, where you can see the blade or wheel turn, multi-tools move attachments so fast that their movement is hard to detect. This high-speed motion, combined with the smaller design of a multi-tool, makes it the tool perfect for small cutting and sanding jobs. Oscillating multi-tools can also be used for scraping grout, cutting metal and PVC piping, removing adhesives and paint, or sanding and preparing different types of surfaces.

One of the most useful characteristics of a multi-tool is its ability to fit into tight, confined places. As a result, they are an excellent choice for undercutting low baseboards, cutting small openings in drywall, or cutting pipe where there is little room for larger tools. Like most other basic power tools, oscillating multi-tools are available in corded versions, but cordless models make up the bulk of those found on today's job sites.

3.3.1 Oscillating Multi-Tool Safety and Maintenance

Follow these guidelines for the safe use and proper maintenance of oscillating multi-tools:

- Always wear the appropriate PPE when working OMTs, especially gloves and safety glasses.
- Disconnect the OMT from its power source when changing the attachment or performing maintenance.

Figure 42 Oscillating multi-tool.
Source: Image property of Stanley Black & Decker. Used with permission

- Confirm that the attachment on the tool is designed for the job being performed.
- Use clamps or vices to securely hold the work piece.
- Never wear loose clothing or jewelry that can get caught on the OMTs attachment.
- Keep your hands away from the attachment when the OMT is turned on.

3.0.0 Section Review

1. A stationary grinder that has two wheels for grinding, removing rust, and buffing metal is a(n) _____.
   a. angle grinder
   b. tandem grinder
   c. bench grinder
   d. end grinder

2. Special rotary bits that can be used on grinders to remove rough edges from the inside and outside of pipes and other objects are commonly called _____.
   a. burr bits
   b. backing pads
   c. coring bits
   d. buffing wheels

3. One characteristic that makes an oscillating multi-tool so useful is its ability to _____.
   a. fit into tight places
   b. drill large holes in concrete
   c. cut through heavy steel
   d. handle large carpentry jobs

4.0.0 Miscellaneous Power Tools

Performance Task

1. Safely and properly demonstrate the use of the following tool:
   - Power nailer

Objective

Identify and explain how to use miscellaneous power tools.

a. Discuss the hazards of using power nailers.

b. Describe jobs that can be performed with hydraulic jacks.

Power tools are used for many applications on a typical construction site. In addition to drilling, cutting, and grinding, some of the more common applications include fastening and jacking. This section covers the following power tools:

- Power nailers
- Pneumatic impact wrenches
- Hydraulic jacks

4.1.0 Power Nailers

Power nailers (*Figure 43*), often referred to as *nail guns*, are common on construction sites. They greatly speed up the installation of materials such as wallboard, molding, framing members, and shingles.

Pneumatic nailers are driven by compressed air traveling through air lines connected to an air compressor. They are designed for specific purposes, such as roofing, framing, siding, flooring, sheathing, trim, and finishing. Nailers use specific types of nails, depending on the material to be fastened. Nails come in coils and in strips, and are loaded into the nail gun.

WARNING!

Never exceed the maximum specified operating pressure of a pneumatic nailer. Doing so will damage the pneumatic nailer and may cause injury.

Pneumatic nailers are designed to fire when the tool is pressed against the material being fastened and the trigger is pressed. An important safety feature of all pneumatic nailers is that the nailer will not fire unless it is pressed against the material.

Figure 43 Pneumatic nailer.
Source: Image property of Stanley Black & Decker. Used with permission

Power Screwdrivers

Power screwdrivers use a power source (this model uses a battery) to speed production in a variety of applications, such as drywall installation, floor sheathing and underlayment, decking, fencing, and cement board installation. A chain of screws feeds automatically into the firing chamber. Most models incorporate a back-out feature to drive out screws as well as a guide that keeps the screw feed aligned and tangle-free. Power screwdriver tools can accept Phillips or square slot screws and weigh an average of six pounds.

Source: Image property of Stanley Black & Decker. Used with permission

The use of powder-actuated anchor or fastening systems has been increasing rapidly in recent years. They are used for anchoring static loads to steel and concrete beams, walls, and so forth.

Powder-actuated fasteners are used to drive steel pins or threaded steel studs directly into masonry and steel (*Figure 44*). An advantage of these tools is that they eliminate the need for compressed air to operate the tool. However, these tools can be extremely dangerous. They look and fire like a gun and use the force of a gunpowder load (typically .22, .25, or .27 caliber) to drive the fastener into the material. The depth to which the pin or stud is driven is controlled by the density of the base material and the power level or strength of the powder load.

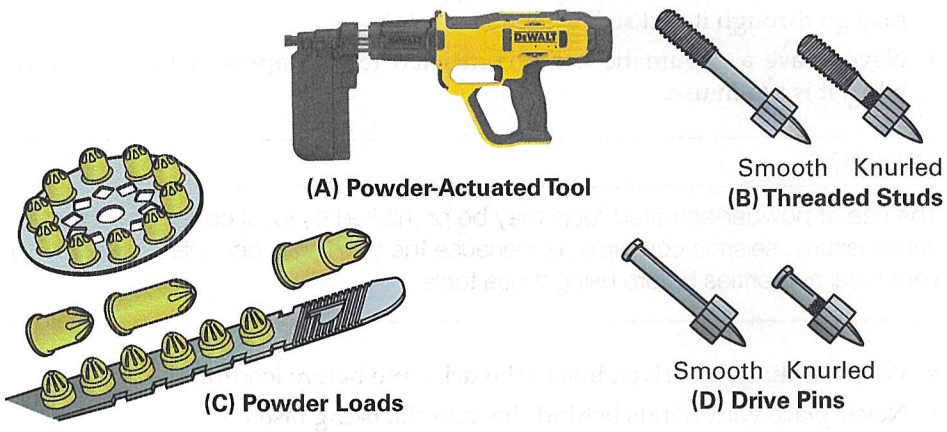


Figure 44 Powder-actuated fastening system.
Source: Image property of Stanley Black & Decker. Used with permission (44A)

WARNING!

Operators of powder-actuated tools must be trained and certified by the manufacturer of the tool being used.

Avoid firing a powder-actuated tool into easily penetrated materials. The fastener may pass through the material and become a flying missile on the other side.

If a powder load fails to fire, wait 10 seconds, remove it from the installation tool, and then dispose of it in a bucket of water or oil.

Figure 45 Cordless electric nailer.
Source: Image property of Stanley Black & Decker. Used with permission

While pneumatic and powder-actuated tools have traditionally been the choice of craftworkers nailing into concrete and steel, cordless electric nailers (*Figure 45*) are another alternative. Cordless nailers are battery operated and have enough power to fasten pins, straps, and clips to concrete and steel. Although they may not have the power that a powder-actuated tool can generate, they are strong enough to handle most concrete fastening jobs. Cordless nailers have several advantages, including the lack of a hose that must be connected to pneumatic nailers. Using cordless nailers also allows craftworkers to avoid the training and certification required to use powder-actuated tools.

4.1.1 Power Nailer Safety and Maintenance

There are numerous safety and maintenance guidelines associated with pneumatic, powder-actuated, and electric concrete fastening tools. In addition to following basic power tool safety guidelines, familiarize yourself with these safety rules before operating a power nailer:

- Always wear the appropriate PPE, especially safety glasses.
- Read and understand the manufacturer's manual.
- When using a pneumatic nailer, pay close attention to where you are pointing the nail gun. Never point the nail gun toward another worker or toward any part of your body.
- Be sure you select the correct nail gun and fastener for the job and never load the tool until you are ready to fire it.
- Never try to operate a powder-actuated tool without the proper training.
- Keep pneumatic nailers oiled according to the manufacturer's instructions.
- Disconnect the power source from the nailer before attempting to load or repair it.
- Always treat nailers as if they are loaded and ready to fire.
- Check for pipes, electrical wiring, vents, and other materials behind wallboard before nailing.
- Be careful about nailing into paneling or any other thin surface. The fastener may go through it and strike another worker.
- Never leave a pneumatic nailer connected to a compressor hose or power when it is not in use.

WARNING!

The use of powder-actuated tools may be prohibited by local codes because of safety issues, seismic concerns, or because the building is occupied. Check with your local authorities before using these tools.

- When loading the driver, install the drive pin before loading the charge.
- Never place your hands behind the material being fastened.
- Do not fire the tool close to the edge of the material, especially concrete. Pieces of concrete may chip off and strike someone.

4.1.2 Operating Power Nailers

The safe and efficient use of power fastening tools depends on careful preparation, following some commonsense guidelines, and being familiar with the tool. Follow these steps to use power nailers properly and safely:

Step 1 Don the appropriate PPE.
Step 2 If using a pneumatic nailer, disconnect it from the air hose.
Step 3 Inspect the nailer for damage and loose connections.
Step 4 Load the fastener into the nailer. When loading a powder-actuated tool, feed the pin or stud into the piston, followed by the gunpowder cartridge.
Step 5 If you are using a pneumatic nailer, connect it to the air hose. Also, check the air compressor and adjust the pressure to the recommended level. Most nailers operate at pressures of 70 to 120 pounds per square inch (psi) (≈480 to 830 kPa).
Step 6 Test the nailing ability of the tool using a piece of scrap material. If the nail penetration is not deep enough, follow the manufacturer's instructions for increasing the power of the nailer.
Step 7 Hold the pneumatic or battery powered nailer firmly against the material to be fastened, then press the trigger (*Figure 46*). If you are using a powder-actuated nailer, position the tool in front of the item to be fastened and press firmly against the mounting surface (*Figure 47*).
Step 8 After finishing the job, disconnect the power source from the nailer. Turn off the air supply and disconnect the air hose from the nailer. Remove the battery from cordless nailers. Remove the powder charge(s) from powder-actuated fastening tools.

WARNING!

A nail gun is not a toy. Playing with a nail gun can cause serious injury or death. Nails can easily pierce a hand, leg, or eye. Never point a nail gun at anyone and use it only as directed by the manufacturer.

Figure 46 Proper use of a nailer.
Source: Zachary McNaughton, River Valley Technical Center

Figure 47 Using a powder-actuated fastening tool.
Source: Simpson Strong-Tie Company Inc.

4.2.0 Hydraulic Jacks

Hydraulic tools are used when an application calls for extreme force to be applied in a controlled manner. These tools do not operate at high speed, but you should exercise great care when operating them. The forces generated by hydraulic tools can easily damage equipment or cause personal injury if the manufacturer's procedures are not strictly followed.

Hydraulic jacks are portable devices used for a wide variety of purposes. They can be used to move or lift heavy equipment and other heavy material, to position heavy loads precisely, and to straighten or bend frames. Hydraulic jacks have two basic parts: a pump and a cylinder (sometimes called a ram). There are various types of hydraulic jacks including those with internal pumps and those that use a lever-operated pump. The latter type is often referred to as a Porta-Power®, the name of one common brand.

A hydraulic jack with an internal pump is a general-purpose jack that is available in many different capacities (*Figure 48*). The pump inside the jack applies pressure to the hydraulic fluid when the handle is pumped. The pressure on the hydraulic fluid applies pressure to the cylinder, which lifts or moves the load.

A typical lever-operated pump kit (*Figure 49*) includes a length of hydraulic hose, a hydraulic hand pump cylinder, and a variety of attachments made for different jobs. Lever-operated pumps are available in different capacities. Cylinders are available in many sizes; they are rated by the weight (in tons or metric tonnes) they can lift and the distance they can move it. This distance is called stroke and is measured in inches or millimeters. Hydraulic cylinders can lift more than 500 tons (≈454 metric tonnes). Strokes range from ¼-inch (≈6 mm) to more than 48 inches (≈122 cm). Different cylinder sizes and ratings are used for different jobs. Lever-operated pumps are especially useful for horizontal jacking.

4.2.1 Hydraulic Jack Safety and Maintenance

Using hydraulic jacks safely and effectively requires an awareness of the area surrounding the load, the load itself, and the jack. In addition to following basic power tool safety guidelines, familiarize yourself with these safety rules:

- Always wear the appropriate PPE, especially safety glasses.
- Operate the jack according to the manufacturer's guidelines.
- Check the area prior to jacking a load to ensure that other workers are safely out of the way and that the load will clear all obstacles.
- Make sure you have the appropriate jack for the job and never exceed its lifting capacity.

Figure 48 Portable hydraulic jack.
Source: Walter Meier Manufacturing Americas

Figure 49 Lever-operated hydraulic pump kit.
Source: Torin Jacks, Inc.

- Check the fluid level in the jack before using it and watch for any fluid leaks during use. If a Porta-Power® is being used, make sure that the hydraulic hose is not twisted or kinked. Do not move the pump if the hose is under pressure.
- Make sure the base of the jack can be placed on a solid, even, and level surface. Never place the base of the jack on bare soil or any other surface that could compact or shift under the load.
- If there is a possibility that the load could move while jacking, make sure it is chocked and restrained. Never jack metal against metal; use wood softeners as a buffer between metal surfaces.
- Place the jack under the load so that the load is centered and the weight is uniformly distributed.
- Stay clear of the object being lifted to avoid injury if the load slips off the jack.
- Do not use an extension bar, or cheater, or step on the pump handle to gain more leverage.
- Never leave a jack under a load as a support.
- Block the load up as you progress through the lift, so that it will only fall a short distance if the jack fails.
- Once at the proper height, add blocking as needed so the load is supported while the jack is removed.
- To reduce tripping hazards, remove the jack's lever any time the jack is not being pumped.

4.0.0 Section Review

1. Pneumatic nailers are designed to safely fire when the trigger is squeezed and the tool is _____.
   a. filled with a charge of compressed air
   b. pressurized with hydraulic fluid
   c. connected to its battery pack
   d. pressed against the material being fastened

2. When using a portable hydraulic jack, be sure to _____.
   a. avoid twisting or kinking the air lines
   b. leave the jack under the load as a support
   c. use an extension bar on the pump handle
   d. place the base of the jack on a solid, level surface

Module 00104 Review Questions

1. Pneumatic tools get their power from _____.
   a. air pressure
   b. fluid pressure
   c. hand pumps
   d. AC power sources

2. When operating a power tool, it is important to always _____.
   a. wear the proper PPE
   b. notify a coworker
   c. wear rubber-soled footwear
   d. ask a co-worker how to operate the tool

3. Using a trigger lock to lock a tool's trigger in an On position _____.
   a. can increase productivity
   b. ensures the tool will have enough power
   c. can be dangerous and cause injury
   d. is a great way to keep your hand from getting fatigued

4. The most common use of the power drill is to _____.
   a. cut wood, metal, and plastic
   b. drive nails into wood, metal, and plastic
   c. make holes in wood, metal, and plastic
   d. carve letters in wood, metal, and plastic

5. A masonry bit is able to drill into concrete and similar material because it has a _____.
   a. countersink shank
   b. ceramic core
   c. whip check
   d. carbide tip

6. An example of an electric power drill that is designed to be used in tight spaces is a(n) _____.
   a. electromagnetic drill
   b. right-angle drill
   c. hammer drill
   d. keyless chuck drill

7. The electromagnetic drill is a _____.
   a. handheld drill used on wood
   b. cordless drill used on masonry and tile
   c. portable drill used on thick metal
   d. pneumatic drill that has a pounding action

8. Hammer drills are designed to drill into _____.
   a. wood, metal, and plastic
   b. concrete, brick, and tile
   c. drywall, fiberglass, and wood
   d. roofing shingles, plastic, and wood

9. Compared to a common drill, an impact driver has _____.
   a. more torque
   b. more weight
   c. more variable speed options
   d. more bits for precision drilling

10. A pneumatic impact wrench requires the use of _____.
    a. impact sockets that are designed for the applicable tool
    b. an adapter so that handheld sockets will fit
    c. shear pins between the wrench and the socket
    d. a trigger lock to prevent accidental starting

11. When cutting with a circular saw, grip the saw handles _____.
    a. and pull the saw toward you
    b. firmly with two hands
    c. firmly with one hand
    d. and engage the trigger lock

12. The high speed setting on a reciprocating saw is used for _____.
    a. cutting through drywall
    b. metal work
    c. grinding surfaces
    d. sawing wood and other soft materials

13. Before using a reciprocating saw to cut through a wall or partition, always _____.
    a. find out what is on the other side
    b. remove the lower blade guard
    c. increase the revolutions per minute
    d. lubricate the guard with oil or grease

14. When using a jigsaw, avoid vibration by _____.
    a. using a low-speed setting
    b. using a clamp or vise to hold the workpiece
    c. setting a heavy object on the workpiece
    d. holding the workpiece down with your free hand

15. Use only a band saw that has a _____.
    a. stop
    b. breastplate with a broad surface
    c. battery pack
    d. thick, three-piece blade

16. A sliding compound miter saw has a rail that allows the blade to slide forward and backward, which enables the saw to _____.
    a. use much thinner blades than a standard miter saw
    b. produce much less dust than a standard miter saw
    c. cut wider material than a standard miter saw
    d. cut harder material than a standard miter saw

17. The blade of an abrasive cutoff saw spins at such a high speed that _____.
    a. the resulting friction is hot enough to burn through the material
    b. it can only be used for straight cuts
    c. the abrasive particles will melt into some metals
    d. it can never be more than eight inches in diameter

18. The end grinder is used to _____.
    a. polish intricate work
    b. grind surfaces
    c. smooth the inside of materials, such as pipe
    d. smooth the work before painting

19. A detail grinder smoothes and polishes intricate metallic work by using attachments called _____.
    a. points
    b. rollers
    c. pins
    d. studs

20. Powder-actuated fastening systems are used to _____.
    a. penetrate drywall and treated wood
    b. anchor static loads to concrete
    c. hammer nails into metal
    d. remove nails

21. Porta-Power® cylinders are rated by how much weight they can lift and by _____.
    a. their torque
    b. the amount of electromagnetic material they have
    c. the distance they can move the weight
    d. how much they weigh

22. Hydraulic jacks are used when the application calls for _____.
    a. operation at high speed
    b. quiet operation
    c. extreme force to be applied
    d. manually assisted lifting

Answers to Section Review Questions and Module Review Questions are found in *Appendix A*.

APPENDIX A Answer Key

Answer	Section Head	Objective
MODULE 00104		
Section 1.0.0		
1. a	1.1.0	1a
2. b	1.2.5	1b
3. d	1.3.0	1c
4. c	1.4.2	1d
Section 2.0.0		
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2. d	2.2.1	2b
3. c	2.3.0	2c
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2. d	4.2.1	4b
Module Review		
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5. d	1.2.1	
6. b	1.2.4	
7. c	1.2.6	
8. b	1.3.0	
9. a	1.3.3	
10. a	1.4.3	
11. b	2.1.2	
12. d	2.2.2	
13. a	2.2.3	
14. b	2.2.4	
15. a	2.3.1	
16. c	2.4.1	
17. a	2.4.2	
18. c	3.1.0	
19. a	3.1.0	
20. b	4.1.0	
21. c	4.2.0	
22. c	4.2.0	

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